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TERRITORY OF NEW GUINEA.

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CONTENTS.

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6034.

CACAO CULTIVATION, AND ITS APPLICATION TO THE MANDATED TERRITORY OF NEW GUINEA.

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Introduction.

The Mandated Territory of New Guinea is in the primary stages of development, and the cultivation of coco-nuts is one of the main sources of revenue. However, the economic conditions prevailing throughout the world during the period 1930-36 were such that the coco-nut industry was scarcely profitable, and, although conditions have since improved, nevertheless it has shown that this country cannot afford to rely solely on one crop.

The argument may be made that investigations to date of the mineral resources of New Guinea show that the Territory has great mineral potentialities. It is pointed out, however, that the "backbone" of a country lies in agricultural and pastoral pursuits, and that mineral wealth merely provides a quick method of economic establishment. Therefore, agricultural and pastoral consideration is important, especially whilst the mineral wealth is available.

The aim of this paper is to set out the methods of establishing a cacao industry as another means of augmenting agricultural development, and the coco-nut industry in particular.

It may be argued that the prices realized for cacao during the "depression" years were barely economic, and that cacao occupies a similar position to copra, so why not consider crops such as coffee or rubber, &c.? The depression period affected other crops in the same manner as cacao and coco-nuts, but so far as this country is concerned, it is known that cacao can be grown in many areas, and there is not the necessity for ample casual labour, specialized labour, and factory costs as in coffee, or the possibility of restriction plus overhead factory costs as in rubber. If New Guinea can produce a high-grade cacao at comparatively low cost the crop should be economical even under moderately adverse market conditions, and, as cacao is a permanent crop, it is essential that the future, and not the present, be considered.

It will be shown later in this paper that the planting material available is excellent and compares favorably with that of Ceylon and Java, whilst it is superior to that of Trinidad—three countries that produce the bulk of the world's high-grade cacao.

In the development of any new industry it is essential that every endeavour be made to profit by the experience of countries in which that industry has already been developed. In this connexion there is the precedent of peasant and estate cultivation in Trinidad, where an Empire Research Scheme is in operation, in Ceylon and Java, where experimental research has reached a high standard of efficiency, and, as a purely native industry, precedent has been established on the Gold Coast, where, in recent years, a great deal of primary investigational work has been carried out.

It will be seen that this country is in a most favorable position for the establishment of a cacao industry, and further, being under the control of the Commonwealth of Australia, it is more than probable that Australia would be

the initial market. The demand for raw cacao, as shown in Table No. 1, is increasing in the Commonwealth, the market is protected for New Guinea beans, and there is a bounty of £14 per long ton on all cacao imported into the Commonwealth from the Territory for home consumption up to the 31st December, 1947.

TABLE No. 1.[6]

Period.	Lb. imported.
1930-31	7,068,214
1931-32	10,825,965
1932-33	13,927,713
1933-34	14,252,722
1934-35	13,105,012
1935-36	14,752,942
1936-37	14,496,214

Australia imports "fine" cacao from Ceylon, Java, Trinidad, and Samoa, and "ordinary" cacao from the Gold Coast,[26] the quantity of "fine" being comparatively high. The border line separating "choice" or "fine", and "ordinary" cacao, lies at about a tannin content of 6 per cent. Cacao containing less than 6 per cent. tannin in the unfermented state is "choice" or "fine", and that over 6 per cent. is "ordinary".[16]

Selection of the Land.

The selection of the correct type of land is essential for the best growth of the cacao tree, and, together with soil, aspect, and facilities for transport, should be carefully considered.

Shallow soil overlying hard rock or soap stone, heavy impervious clay or very light sandy soil, soils subject to water-logging, and hillsides that have been eroded, are to be avoided as being quite unsuitable for the profitable cultivation of cacao. The most suitable soil is one that is deep, friable, easily drained, and containing a large amount of organic matter. The nearer the soil approaches these characteristics, the better should be the growth of the cacao. Soils derived from pumice, and containing a fairly deep humic layer, such as are found in portions of the Gazelle peninsular, support quite good cacao growth, especially in the early stages. This type of soil, however, retains moisture very badly, and climatic variations have a more direct effect on the crop. Further, once cleared for cultivation the organic matter is depleted rather rapidly, and provision for continual addition is necessary.

The soil can, to some extent, be selected in practice by observing its mechanical nature, and, if the local flora is understood, then the nature of the vegetation helps. Samples of the soil submitted to a qualitative and quantitative mechanical and chemical analysis would be of general assistance in selection. It is, however, rightly pointed out by Hart[13] that land for cacao cultivation should not be selected on chemical analysis alone, as it is possible for soils to contain the essential substances in sufficient quantities required for growth, but such substances may occur in forms unavailable for absorption by the plant. For instance, many soils of volcanic origin contain iron in such a form that, although present in quantity, it is unavailable on account of its combination.

In writing further on soil analysis, Hart[13] quotes Johnston[14] as saying that "chemical analysis of a soil as ordinarily conducted, valuable though it is in some respects, is not of much service in indicating the actual fertilizing matters

at the moment available in the soil. The agencies at work, whereby the elements of fertility are rendered available for the plants' use, are so complicated and numerous that the best test of the soil's fertility is to carry out experiments with the plant itself ".

That it is inadvisable for a planter to select an area of land, plant a small portion, and wait to observe the growth of the cacao, is realized. He can, however, note the flora, observe the growth in native gardens in the vicinity and on similar soils, and from such information, as well as local inquiries, plus the physical properties of the land, and, if possible, interpretation of an analysis by a competent authority, decide on its suitability for cultivation.

With regard to aspect, any site that is exposed to heavy prevailing wind, or constantly strong sea breezes, should be avoided unless there are facilities for planting efficient wind-breaks. The ideal spot is one that is sheltered and well protected from prevailing winds by hills and spurs.

The selection of land with easy access to a suitable harbour or anchorage is important, and care should be taken to see that loading facilities, if not available for the whole year, are at least suitable during the greater part of the year. If dried cacao requires to be lightered to the steamer or schooner, then any exposed portion of the sea may prove troublesome, in so far as the produce is liable to wetting. Furthermore, any large capital expenditure necessary for the construction of roads to the loading site or the main road decreases considerably, in the case of the individual planter, the sum available for development.

Felling and Clearing the Forest.

In certain parts of the world, felling and clearing is carried out under contract, or, as in Trinidad, the planter can receive some remuneration from his land by leasing that portion to be planted to individuals for the purpose of felling, and converting the large trees into charcoal.

In New Guinea, the general apathy of the natives makes them unreliable for contract clearing; there is no charcoal industry, and unless the planter can arrange to log or mill his timber he must carry out his own operations.

The writer is of the opinion that the best method of clearing is to concentrate on felling during the wet season, and, in the following dry season, clear the land and prepare for planting at the commencement of the next wet season. This system certainly delays planting to a slight extent, but experience on the volcanic type of soil at the Demonstration Plantation, Keravat, has proved that burning-off is expedited when the heavy timber is dry; also, the soil is improved by the addition of the material resultant from the soft wooded trees, leaves, &c., rotting during the months prior to burning. Furthermore, the short, dense growth of secondary bush which follows the initial felling can be brushed and allowed to rot into the ground whilst the heavy timber is being burnt. The rotting of this secondary material further increases the humus content, and improves the soil. The light-textured, open, volcanic soils in many parts of the Territory are prone to lose a great deal of their initial fertility when exposed for any length of time, and the more protection that can be afforded by the judicious use of softwoods, leaves, &c., the less likelihood of rapid deterioration through clearing.

In felling, the smaller trees, shrubs, vines, &c., are cut first of all, after which the large trees are dropped, lopped so that the foliage lies flat on the ground, and

if desired, whilst still green cut into convenient lengths for handling. Cutting up whilst still green has the advantage that the logs dry out much quicker, an important factor if burning-off closely follows felling.

The question as to whether the heavy timber should be burnt or merely rolled out of the way for lining is rather contentious. Burning kills the weeds, and clears the land of debris that provides shelter and breeding places for insect pests that could be injurious; it also assists greatly in preventing many tropical trees from sprouting from the stumps, reduces to a minimum fungal infection from rotting stumps, facilitates lining and planting the shade and ground cover, and assists in supervision. On the other hand, it is claimed that burning destroys a great deal of the fertility of the upper layers of the soil, the fertilizing effect of the timber is reduced, and on hillsides the loss of soil by erosion is increased.

It is considered that if the heavy timber is arranged in large heaps as far apart as is economical, then the disadvantage, such as loss of fertility in the upper part of the soil, would be reduced, and the effect on weeds, insect pests, and

Plate No. 1.

Plate No. 2.

sprouting of the stumps, would tend to outweigh the loss in fertilizer and erosion. In any case the adoption of some form of soil protection, such as the planting of cover or shade crops, should be practised as soon after clearing as possible, whether the land be burnt off or not, as the case may be.

The removal of stumps is most important, as they provide ideal hosts for fungal parasites such as *Rigidoporus microporus* and *Armillaria mellea,* which can later infect the cacao roots when they come into contact with infested stump roots. Furthermore, fungi of this type can move through the soil for some distance from the host, and so cause infection without actual contact with infected stump roots taking place.

Plate No. 1 shows the virgin forest in the background, heavy standing timber in the left foreground, and fallen bush in the centre foreground.

Plate No. 2 shows the land with only the heavy timber remaining on the ground, leaves, soft-wooded trees, &c., having rotted into the soil.

Plate No. 3 shows the land practically cleared—the few remaining stumps will be grubbed out before planting. It will be noted that a certain amount of rubbish covers the surface of the ground.

In Plate No. 4 the hillside shown in Plate No. 3 has been contour-lined and planted with sweet potatoes to prevent erosion and provide native food for the plantation labour.

Plate No. 3.

Plate No. 4.

Plate No. 5.

Plate No. 6.

In Plates Nos. 5 and 6 will be seen standing crops of maize and kaffir corn, respectively, planted for quick ground protection in addition to native food.

In some countries(12) it is customary to leave certain of the larger forest trees standing to provide shade for the young cacao. This practice is not to be recommended, because only special trees are suitable, and such shade is not regular. Further, in a climate such as New Guinea, where the rainfall is heavy, the question of shade density must be determined in individual localities, and it is

advisable to plant a cultivated tree that can be pruned, or removed if the occasion arises. Again, the forest trees in many cases having no tap root, tend to be blown down when the surrounding vegetation is cleared; their rooting system is already established, and the young cacao seedlings do not get an equal chance in the competition for soil nutrients.

To leave wind-breaks of natural forest through the cacao fields is not advisable, owing to the risk of the trees falling prematurely due to wind. There are, however, circumstances in which a belt of natural forest may be left along the boundary of the estate, or a beach frontage.

Drainage.

After the forest has been cleared, the contour of the land is more easily seen, and any necessary areas can be drained.

The height of the water table in the soil is important, and it is advisable to ascertain its depth before attempting to drain. This may be carried out in a practical manner during the wet season when the soil is carrying a maximum amount of moisture, by digging numerous holes. Then, when the drains are made they can be dug in such a manner as to maintain the water table at a depth of at least 3 feet.[12] The open type of drain is the most suitable, and care should be taken to see that the sides have a reasonably good batter, especially in soils derived from pumice. It is advisable to utilize natural streams and watercourses as main drains, and the size of the subsidiary drains will depend on the amount of water to be carried.

The idea held by many people that drains are unnecessary on hillsides, especially where the slope is fairly steep, is wrong. Drains must be dug to assist in preventing too rapid a run off following heavy rains. The menace of soil erosion cannot be too strongly stressed, and the extent of erosion is correlated with rainfall intensity and frequency—two factors ever present in this Territory. Therefore, land that is subject to erosion should be protected to the utmost, and in addition to providing vegetative means of soil protection, shallow contour drains should be dug to diminish the velocity of the surface water.

Preparation of the Land for Cultivation and General Layout of the Estate.

It is a recognized fact that tropical soils lose a great deal of their fertility after the forest has been cleared if the land is allowed to remain unprotected.

Reference to Plates Nos. 4, 5 and 6 will show recently cleared land planted with sweet potatoes, maize and kaffir corn, to provide soil protection until the temporary shade is fulfilling this duty. Pea-nuts and cow-pea are two very useful crops that may also be employed as soil protectors in the same manner as sweet potatoes or maize. They have one very great advantage over the other crops in that they are leguminous and improve the soil by their growth. In addition to the foregoing crops, cassava, taro, mammees and bananas may also be planted to provide protection and native food, but these species, together with sweet potatoes, remove a great deal of nutrient from the soil, and, in the case of cassava, difficulty in eradication after harvest is generally experienced.

Many authorities[12, 20] are of the opinion that cassava exhausts the soil, and there appears to be little doubt that this crop does draw to a large extent on the soil nutrients, but apart from its possible effect on the soil fertility, cassava as a

temporary shade has other disadvantages; supervision costs are increased and shade regulation difficult on account of the density of growth, and, once established, eradication is difficult and costly.

Sweet potatoes and mammees, providing the latter are not staked, are worth cultivating; a certain amount of tillage is required prior to planting, the soil is adequately protected, and future eradication is not so difficult. There would be a little extra maintenance necessary to keep either crop from smothering the temporary or permanent shade in its early growth.

There are two types of taro used in this Territory for native food purposes; native taro (*Colocasia* spp.), and Kong-kong taro (*Xanthosoma* spp.) The former may be used as a catch crop, but for weed and grass control it is of little value; the latter is a large stemmed, large leafed species that effectively controls grasses and weeds, but the disposal of the stem portion after harvest is rather difficult, and the crop is a heavy feeder. It is under trial at the Demonstration Plantation, Keravat, as a temporary shade/catch crop, but appears to have very limited possibilities in this direction.

Maize and kaffir corn are quick growing grain crops that are very useful as soil protectors in the early stages of development, and maize provides an excellent native food. The useful period of maize as a shade is three months, by which time the temporary leguminous shade should be established. Kaffir corn will last a great deal longer, at least nine to twelve months, but its dense growth necessitates periodical thinning in order to allow the temporary leguminous shade to come away. Where establishment of the cacao is required quickly, kaffir corn has possibilities as temporary shade instead of leguminous shade, as it becomes established very quickly, and, if need be, the cacao could be planted in the field approximately eight to ten weeks after planting the kaffir corn.

As a grain it is used in other tropical parts of the world, is easily harvested and the grain can be quickly threshed. Limited trials of kaffir corn as a food for native labourers have been made but the introduction of a new crop to the native diet is extremely difficult, and, until extensive trials have been conducted, the usefulness of this crop must remain one of providing quick temporary shade to expedite planting.

Mention is frequently made in standard text books regarding the usefulness of bananas for temporary shade, ground protection, and food. The banana is a heavy feeder, and this factor, plus the difficulty of thoroughly removing the corms when the permanent shade is established, and the constant thinning out that is needed, renders its use inadvisable.

For New Guinea conditions, it is considered that the data available regarding the use of a combined shade and catch crop are as yet insufficient; therefore, it is preferable to rely on the cultivation of known leguminous crops for temporary shade, and, where necessary, food crops may be planted in conjunction, providing, of course, the food plants do not interfere with the necessary care and attention to be given to the young cacao.

There are two types of leguminous crops which provide ground protection, namely—

(*a*) Creeping;

(*b*) Erect shrubby,

the latter type (*b*) being dual purpose in that they are also used as temporary shade.

The following species, of which some are already under cultivation in New Guinea, are described. It will be seen that certain types are not considered suitable, but have been included because they are commonly known, and inquiries relative to their use are often made.

(*a*) Creeping Covers.

Calopogonium mucunoides.—A quick-growing plant which can be easily propagated from seed or cuttings, is a strong grower, grows well on most soils, but requires fairly good drainage, and is intolerant of shade. On account of its rampancy under suitable conditions, constant attention would be necessary to prevent it from over-running the young cacao and shade. It has a decided tendency to die back during certain periods of the year, and in many parts of the Territory is attacked by a disease similar to Mozaic. *Calopogonium mucunoides* is not considered suitable for use in cacao cultivation.

Centrosema pubescens.—Another quick-growing plant that is easily established by seed or cuttings, has a fairly deep rooting system compared with others of the same type, is effective in controlling weeds, and can withstand long periods of dry weather. It prefers the better class soils, and like *Calopogonium mucunoides* requires careful and regular attention to prevent over-running. This rampancy of growth which necessitates frequent checking makes crop establishment costly, and for this reason *Centrosema pubescens* is not recommended.

Dolichos hosei.—Is a quick-growing plant, easily propagated by seed or cuttings, effective in checking erosion on hillsides,[12] is a good soil builder, and gives a quantity of leaf mulch. *Dolichos hosei* is not a rampant grower or climber, will effectively control grass and weed growth if planted on clean ground, and is not affected by shade. Is an excellent ground cover for cacao and recommended for use.

Desmodium scorpiurus.—This plant, which appears to be indigenous to New Guinea, is remarkably quick growing and easily propagated from cuttings. It grows well under even dense shade, does not climb, forms a very dense mat, and controls grasses and weeds. *Desmodium scorpiurus* has only recently been introduced into cultivation, and at the Demonstration Plantation, Keravat, is proving the best permanent ground cover for cacao.

Indigofera endecaphylla.—This plant can be propagated by seed or cuttings, grows quickly and forms a dense cover, does not climb very much, withstands fairly dry weather, and, although periodically attacked by caterpillars, it quickly recovers. It is inclined to be intolerant of shade, and requires some attention during its early stages of growth. *Indigofera* is quite a suitable cover for cacao, but not nearly as efficient as *Desmodium scorpiurus* or *Dolichos hosei.*

Mimosa invisa.—This quick growing, rampant, thorny plant is easily propagated from seed or cuttings. It is one of the finest soil renovators cultivated but should never be planted as a cover in cacao on account of its rampancy and thorniness. It is considered that *Mimosa invisa* has definite possibilities on open grass or kunai (*Imperata arundinacea*) land if allowed to grow unrestrained for two or three years, then cut and ploughed under prior to preparing the ground for cacao.

Peuraria javanica.—Another quick-growing rampant plant which may be established from seed or cuttings. It is a good soil improver, depositing an

enormous quantity of leaf mulch, but, like *Mimosa invisa,* should never be planted as a cover in cacao. *Pueraria* could be used with effect in open grass or kunai land by treating in the same manner as *Mimosa invisa.*

Vigna catiang.—This annual legume is remarkably quick growing, and, in six to eight weeks, forms an excellent cover for protecting the soil. Its usefulness, according to the variety, varies from three to nine months, and it is recommended for use where a quick cover is required immediately after clearing, or where humus deficiency is suspected. When approaching the maximum period of usefulness, cow-pea should be turned into the soil, and replaced by a permanent creeping cover.

(*b*) Erect Shrubby Covers.

Aeschynomene americana.—A quick-growing plant which is easily propagated from seed, grows to a height of 4 to 5 feet, and has spreading branches which commence at ground level. After growing approximately nine months, it seeds profusely and then dies, but quickly re-establishes itself from its own seed. *Aeschynomene* has been in cultivation at the Demonstration Plantation, Keravat, for the past three years, and indications favour its adoption under certain circumstances when a quick cover is required after clearing. The height to which it grows, and its tendency to die off, precludes its use as a temporary shade for cacao.

Crotalaria anagyroides.—This shrub is readily raised from seed, will last from eighteen months to two years, yields a large amount of green material which decomposes quickly, has a moderate rooting system, and will stand frequent prunings when young. *Crotalaria anagyroides* is very susceptible to pink disease (*Corticium salmonicolor*) especially on old wood during its mature stages of growth. It is attacked at all stages by species of hemiptera, and is easily blown down by a moderately strong wind. This species is recommended by authorities as a temporary shade for cacao, but the writer is of the opinion that, as a sole crop, its disadvantages outweigh its advantages, and that it should always be planted in conjunction with *Tephrosia candida* or *Leucaena glauca.*

Cajanus indicus.—This species is readily raised from seed, and will last about two years, the seeds provide an excellent food for human consumption, and the fallen leaves add a lot of humus to the soil. At the Demonstration Plantation, Keravat, where the rainfall ranges from 109 to 125 inches per year, it grows well during its early stages and up to flowering, after which, it becomes most susceptible to pink disease and thread blight (*Corticium* spp.), and the leaves and young pods are heavily infested with insect pests.

Leucaena glauca.—A description of this species will be found under the heading of permanent shade, as it is capable of fulfilling this duty in addition to its suitability for temporary shade or green manuring. As temporary shade, it should be planted at least six months before the cacao.

Tephrosia candida.—This shrubby plant is easily propagated from seed and attains a height of 6 to 8 feet in a comparatively short time. It retains its usefulness up to three years, yields a large amount of green material (Macmillan[19] quotes up to 58 tons per acre from four prunings), stands frequent lopping very well, and has the ability to grow on poor soils. It is subject to pink disease which attacks the older wood in the mature stages, and the seed pods are

attacked by caterpillars. *Tephrosia candida* has a deep and strong rooting system, will withstand heavy wind, and is considered by the writer to be the best dual purpose ground cover temporary shade that can be used for cacao in this country.

Tephrosia vogelii.—This species closely resembles *Tephrosia candida* but does not grow so high, nor is it so permanent, its economic life being about one year. *Tephrosia vogelii* yields a larger amount of green manure when young than *Tephrosia candida,* has large hairy seed pods, and is easily propagated from seed, but as a dual purpose plant, it has the disadvantage of being shortlived and extremely susceptible to pink disease.

In the following table No. 4[7, 20] analysis of the green material of many of the foregoing listed plants is shown :—

Species.	Moisture.	Org. Matter.	Ash.	Nitrate.	Lime.	Potash.	Phosphate Acid.
C. mucunoides (20)	74.7	22.5	2.8	1.1	.79	.46	.14
C. pubescens (20)	65.5	32.3	2.2	1.39	.60	.34	.08
D. hosei .. (20)	79.9	17.8	2.3	.71	.43	.39	.18
I. endecaphylla (20)	74.7	22.1	3.2	.78	.90	.41	.12
C. indicus (7)	54.5	..	1.86	.64	.34	.51	.25
C. anagyroides (20)	72.8	25.4	1.80	1.32	.53	.38	.10
T. candida (10)	64.4	33.8	1.8	1.72	.66	.49	.18
T. vogelii (7)	73.9	..	2.64	1.07	.70	.69	.19
L. glauca (7)	75.0	..	1.55	..	.42	.38	.07

In addition to the consideration of temporary shade which is essential for the growth of young cacao, and/or creeping cover crops, the utilization of permanent shade must also be given attention, and the question arises as to whether it is, or is not, required.

It has been stated[12, 24] that in some countries cacao can be successfully cultivated without shade, and Grenada is quoted as an instance. In view of the fact that climatic conditions in that country approximate those of New Guinea, it may be argued that an industry can be developed in the latter colony without resource to shade.

Investigations have shown that in Grenada it has been found necessary to use windbreaks, to fork and manure the soil frequently, and to have the land thoroughly drained.[25] Further, a great deal of the land in Grenada is hilly, and, during the day much of the land is shaded by the hills themselves. Therefore, the same degree of protection is not required as when level or slightly undulating land is cultivated. Frequent forking and manuring is expensive and costs of production are unnecessarily increased, so, why increase costs when the use of shade, especially leguminous trees, will enrich the soil with nitrogen by supplying humus, and, as one authority says, "Preserve the humus and texture of the soil by the shade they afford".[12]

In discussing shade, Hart[13] states that a densely shaded estate is more subject to the attack of fungus diseases, but points out that when the shade is insufficient insect attack is more liable to occur. Further, cacao comes into bearing quicker under shade and maintenance is cheaper as the weedy undergrowth associated with unshaded land does not appear.

Experience in New Guinea has shown that insect pests such as the grey weevils (*Platyacus ruralis* and *Coptorrhynchus spp.*), and a small chrysomelid beetle (*Rhyparida obscuripennis*), which are quite serious, are effectively controlled by shade.

The writer considers that arguments against shading are inconclusive, and, in a country like New Guinea, where a new industry is being established, it is advisable to adhere to the general practice in cacao cultivation. It is recorded(13) that in 1865 a paper on cacao cultivation was read before the Scientific Association of Trinidad by a Mr. Law, who was about to commence planting cacao on the island. Mr. Law believed that after the third year cacao did not require shade, and he planted according to this belief. He spent a lot of money on establishment and estimated that his 200 acre plantation would be worth about $47,705 at the end of seven years. His plantations failed and were sold, but, at present, are yielding good crops as they are owned by men who believed in, and planted shade. It must be realized, however, that the shade problem has yet to be investigated in New Guinea, and it is preferable to plant leguminous trees whose shade can be regulated, and, if necessary, removed or thinned out without damage to the cacao.

The type of tree favoured in the West Indies and certain central and South American countries, is the *Immortelle,* a large soft-wooded tree of the *Erythrina* species. In Nicaragua the main shade tree is *Gliricidia maculata,* a medium-sized, quick-growing tree that yields a large amount of green material and stands frequent lopping. In New Guinea where, as already mentioned, shade experimentation is essential, even in individual localities (rainfall, &c., is so variable), the *Immortelle* is too large and difficult to control, and *Gliricidia maculata* is so brittle, and appears to develop such a poor root system in light textured soils that a great deal of damage is caused by falling limbs, or trees falling over. It is possible, however, to overcome this weakness to a large extent by propagation from seed.

Inquiries are often received regarding the use of secondary bush as temporary shade, and large forest trees as permanent shade. There appears to be no reason for using secondary bush; even the advantage, if any, of a saving in original clearing expenses, is offset at a later stage when the secondary bush is cut out. Shade regulation is practically impossible; lining is more difficult; the trees are quick-growing softwoods that are easily blown over; they provide a harbouring place for insect pests; there is likelihood of damage to the young cacao when the trees are cut out; they are for the most part non-leguminous, hence, do not improve the soil; and are in constant competition with the young cacao for nutrient. The reasons why large forest trees should not be used for permanent shade have already been given under the heading of felling and clearing.

The following leguminous trees are considered worthy of attention for permanent shade purposes, especially *Leucaena glauca* which at the present time appears to have most of the necessary features.

Adenanthera pavonica.—This tree, commonly known as the "Bead Tree", grows quickly from seed, and is tall and slender with moderately feathery foliage. The growth of *Adenanthera* at the Demonstration Plantation, Keravat, is most promising, although it appears to require a well-drained soil, exhibits a certain susceptibility to pink disease, and occasionally is broken by wind.

Albizzia spp.—Included in this group are *A. moluccana, A. lebbek* and *A. sumatrana.* They are quick-growing trees with fine feathery foliage, and the timber from *A. moluccana* is soft and suitable for tea boxes, &c.(21) *A. sumatrana*

is periodically attacked at Keravat by a small caterpillar which absolutely defoliates the tree.

Erythrina lithosperma.—This medium-sized tree is easily propagated from cuttings 3 to 6 feet long, planted 18 inches deep. It grows quickly, and, if kept free of side branches, will form a head at about 25 feet, will stand lopping about thrice annually, yields a large amount of green material, and has an economic life of ten to fifteen years. *Erythrina lithosperma* is used extensively in Ceylon,[20] but has been replaced to a large extent by *Leucaena glauca* in Java[12] where it is subject to a number of pests and diseases, and the wood has no economic use.

Leucaena glauca.—A smaller tree than any listed above, flourishes from sea level to 4,000 feet, is easily esablished from seed, and during the wet season, may be propagated from cuttings. *Leucaena glauca* is the most popular shade tree in in Java for cacao, is an excellent soil preserver and improver, stands frequent pruning, and is generally not affected to any great extent by diseases or pests, although there are isolated instances in New Guinea of attack by root fungus (mostly traced to rotting stumps left after clearing), and infestation by mealy bug in one instance has proved serious. This possibility of mealy bug infestation of *Leucaena glauca* should not be overlooked, and the advisability at present of establishing a combination shade, rather than a sole shade, is worth consideration.

L. glauca has a feathery type of foliage, the leaves and young branches are readily eaten by cattle, it provides a light filtered shade, the wood makes good fuel, and the seeds, when boiled and crushed, are excellent cattle food. This species may also be used as a temporary shade or green manure, and is useful as a contour hedge on hillsides.

The following interesting comparison between the leaves of *Leucaena glauca* and goat droppings, after conversion into dry matter, is taken from De Sornay's figures,[7] and serves to illustrate the manurial value of *L. glauca*:—

——	In 100 parts of goat manure.	In 100 parts of *L. glauca* leaves.
Ash	25.00	9.26
Nitrogen	2.48	2.52
Phosphoric acid ..	1.00	.45
Potash..	2.32	2.38

Peltophorum inerme.—This quick-growing, moderately-sized tree, which reaches a height of 25-30 feet in five to six years, is easily propagated from seed, and has a symmetrical top and five bipinnate leaves. *P. inerme* is worthy of consideration as a permanent shade or windbreak, and is under experimentation at the Demonstration Plantation, Keravat, where indications are favorable as a shade, although a certain amount of annual pruning will be required.

The following Table No. 5 shows the analysis of the green material from *Erythrina lithosperma, Leucaena glauca,* and *Albizzia lebbek*:—[7]

TABLE No. 5.[7]

Species.	Moisture %.	Org. matter.	Ash.	Nitrogen.	Lime.	Potash.	Phosp. acid.
E. lithosperma (leaves and tender stems)	69.8	28.4	1.8	1.09	.58	.34	.14
L. glauca (leaves and stems) ..	75.00	23.45	1.55	.85	.42	.39	.07
A. lebbek (leaves only).. ..	67.35	30.04	2.61	1.19	..	.98	.18

The method of laying out the plantation will depend on whether the planter desires to—

(*a*) Establish the cacao by utilizing portion of the land between the rows for the production of native food for his labour;

(*b*) Establish the cacao by using another permanent quick-maturing crop such as coffee.

(*c*) Establish the cacao by the use of leguminous creeping and erect shrubby plants:

(*d*) Establish the cacao as an interplanted crop with coco-nuts.

The following systems covering the headings (*a*), (*b*) and (*c*) are suggested for consideration and outlined below; establishment as an interplanted crop with coco-nuts will be discussed separately. As planting distances and systems of lining will be considered later, it is proposed to adopt 15 feet by 15 feet as an arbitrary measurement for the purpose of illustration.

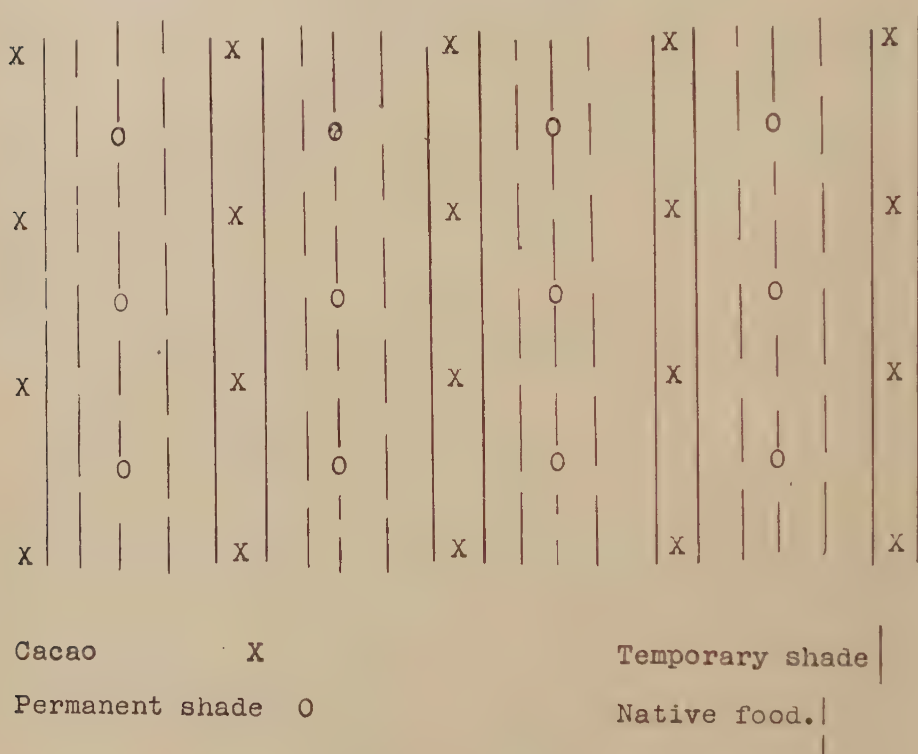


Figure No. 1—Method A.

The cacao is spaced 15 feet by 15 feet, with a row of temporary shade comprising *Crotalaria anagyroides* plus *Tephrosia candida* or *Leucaena glauca*; *Tephrosia candida*, or *Leucaena glauca*, 3 feet distance on each side and planted in the form of a hedge. The permanent shade of *Leucaena glauca*, *Erythrina lithosperma* or *Peltophorum inerme* is planted between the rows of cacao at a distance of 15 feet in the following manner: *Leucaena glauca* and *Erythrina lithorsperma*, or *Leucaena glauca* and *Peltophorum inerme*, or *Erythrina*

lithosperma and *Peltophorum inerme* in alternate rows. The reason for the alternate planting is that, as the shade density and suitability of species must be determined experimentally on each estate, the three shade trees can be regulated with little difficulty, and, if it proves necessary to thin out or discard one species, then the distance apart of the remaining trees will be reduced to a minimum of 30 feet. Should this distance be too close, then facilities are available for thinning out to 45 feet or even more. It must be remembered that the permanent shade is very dense, and therefore will require constant pruning and lopping until the most suitable shade is evolved.

Although three species of shade trees are mentioned and alternate planting suggested, the planter is not bound to adhere strictly to any of the given methods of layout. The writer has closely studied the merits of *Leucaena glauca* and considers this tree to be eminently suitable for cacao, but it must be remembered that probably *L. glauca* may prove difficult to establish in certain areas and under certain conditions, and a combination including another species minimizes the effect on the cacao by irregularity in shade.

The native food can be planted in rows, in the space intervening between the temporary shade.

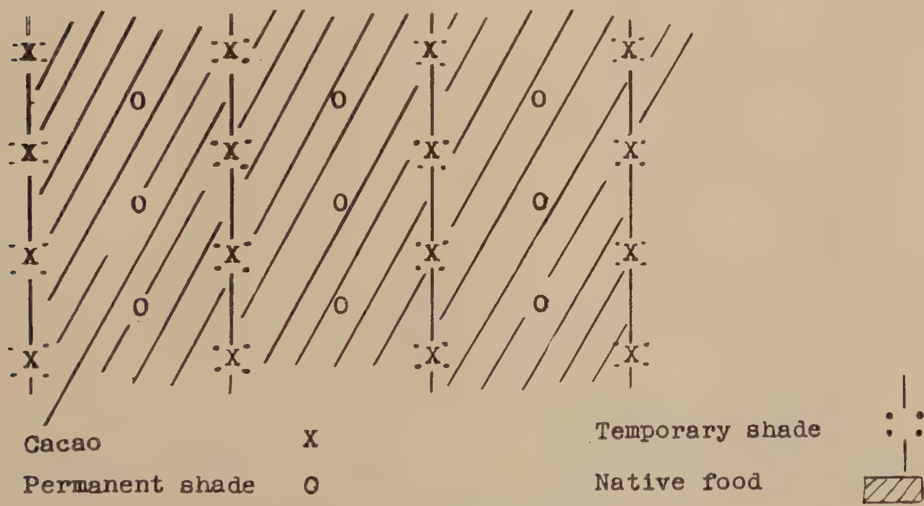


Figure No. 2—Method A.

The cacao and permanent shade are planted in a similar manner to Fig. No. 1. The temporary shade follows the lines of cacao in the form of a hedge, and should the shade be considered insufficient, then a few seeds are sown in a circle of 2-3 feet radius around each cacao seedling. This method allows for quick planting after clearing, as the temporary shade circle around the young cacao can be kaffir corn instead of the customary leguminous shade.

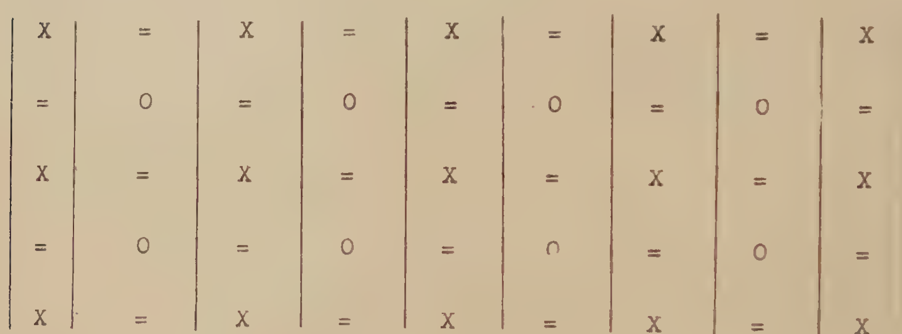
The intervening area between the rows may be planted with native foods, upland rice or maize. If rice be planted it should be sown in rows approximately

1 foot apart with the plants 9 inches to 12 inches apart in the rows. Where maize is planted it should be sown in rows 2 feet to 2 ft. 6 in. apart, with the plants about the same distance apart in the rows.

When using native taro (*Colocasia* spp.), it is advisable to plant in rows 2 feet apart with the plants 2 feet apart in the rows, so that sufficient shade is forthcoming to protect the soil, and at the same time control grass and weed growth.

For maximum yields of tubers, well-grown, healthy suckers should be planted in holes approximately 9 inches deep, and only about one-third of the hole filled with soil after insertion of the tuber.

It might be mentioned that the sowing of temporary shade around the cacao seedlings will depend upon the variety of native food cultivated.



Cacao X   Bananas =

Permanent shade O   Temp. Leg. Shade |

Figure No. 3—Method A.

The cacao and permanent shade are planted in the same manner as in the previous illustrations. Bananas are spaced 15 feet by 15 feet, following the rows of cacao and permanent shade. The reason for including the temporary leguminous shade in this system is to maintain the humus content by green manuring, and as a ground cover until the bananas are fulfilling their duty. Once the duty of the legume has been performed it can be heavily pruned and cut out.

Although this system is included as a possible method of cacao establishment, the suitability of bananas is a most vexed question. A great deal of after-cultivation is essential to keep the stools reduced, and much labour is required for cutting them out after they have fulfilled their purpose. The banana is a heavy soil feeder, and there is ever present the danger of damage to the young cacao from petty larceny of ripe bananas by native labourers, who, following the native custom, cut down the whole plant without thought to where it may fall.

The coffee is planted 15 feet by 15 feet, following the rows of cacao and permanent shade, which is sown in the same manner as outlined in the previous schemes. The temporary leguminous shade is planted the same as in Fig. No. 3, and should be thinned once the coffee has grown to a height of about 2 feet. It is considered inadvisable to cultivate native foods in this system, as it is doubtful whether field foods would provide sufficient humic matter if the leguminous temporary shade were eliminated. However, should the necessity to cultivate native foods be urgent, it is possible that Fig. No. 2 could be modified to suit the requirements, by the addition of another line of temporary shade following the coffee and permanent shade row, thereby enabling the substitution of a suitable food crop for the temporary shade as shown in this illustration.

X	=	X	=	X	=	X	=	X
=	0	=	0	=	0	=	0	=
X	=	X	=	X	=	X	=	X
=	0	=	0	=	0	=	0	=
X	=	X	=	X	=	X	=	X
=	0	=	0	=	0	=	0	=
X	=	X	=	X	=	X	=	X

Cacao	X	Temporary shade	|
Permanent shade	0	Coffee	=

Figure No. 4—Method B.

Should it be assumed that the cacao is yielding an economic return after a period of seven years, then, as the coffee will come into bearing in the third year, the planter should be assured of some return for his investment commencing from the third year. Further, the coffee can be manured for increased yields, and the young cacao would benefit.

There are two important factors to consider when establishing under this system, and they are—

(1) The planter must be prepared to cut out the coffee once the cacao has reached an economic bearing age.

(2) The likelihood of ingress of root fungi if the coffee stumps and roots are not properly removed.

To procrastinate year after year, once the cacao has reached the economic stage, means that both crops will suffer if the coffee is not removed, and, as the coffee

was planted primarily as a catch crop, it should be eliminated once this purpose has been fulfilled unless the cacao does not thrive at all, in which case the coffee might be left and the cacao removed.

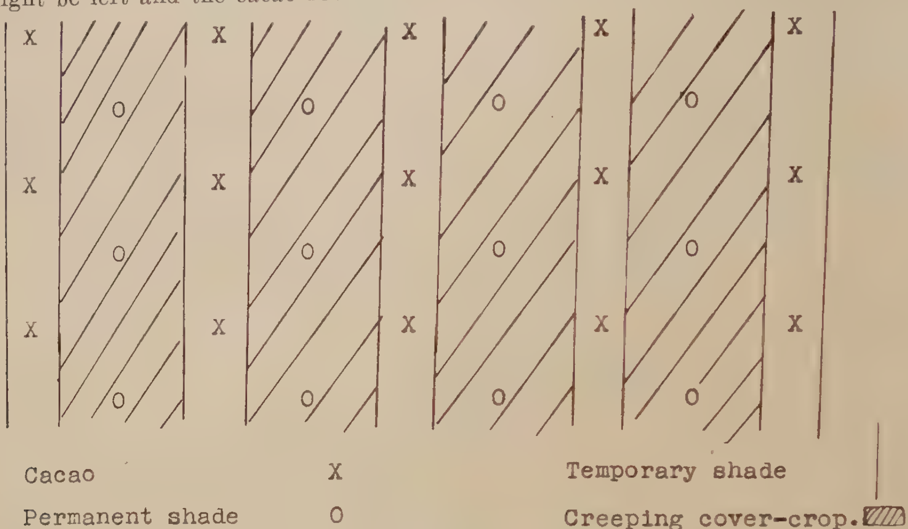


Figure No. 5—Method C.

This scheme is the same as that outlined in Fig. No. 2, so far as the planting of the cacao and permanent shade is concerned, but a creeping leguminous cover crop has been substituted for the native food. In this system cowpea could be planted immediately after clearing and later turned under as green manure and replaced with *Desmodium scorpiurus* or *Dolichos hosei.*

Plate No. 7.

Plate No. 8.

Plate No. 7.—Illustrates land cleared and lined for cacao.

Plate No. 8.—Illustrates the area shown in Plate No. 7 with *L. glauca* on the right, and *T. candida* on the left.

CACAO AS AN INTERPLANTED CROP WITH COCO-NUTS.

The practice of interplanting coco-nuts with cacao is receiving a great deal of attention in New Guinea at the present time.

The system adopted is to plant the cacao in the intervening spaces between the coco-nuts, that is, in the same line as the coco-nuts and between the line of coco-nuts. The palms are interplanted at all ages from eighteen months to two years up to 30 or 40 years old.

Theoretically, interplanting is not advisable because the soil nutrients are doubly taxed to provide for the growth and production of two permanent crops, but, from the practical aspect, there are certain factors which may justify interplanting. It is argued by many that interplanting is necessary on estates where there are uneconomic sections unless copra is a relatively high price, or where the ground flora is dense Kunai (*Imperata arundinacea*), or where the estate is small, profits are small, and no further land is available for alienation. Other factors, such as the need for the diversification of crops, and the interplanting of sections of a young estate as a catch crop, may also be included.

The interplanting of uneconomic coco-nut areas raises the question as to whether such areas can be interplanted with cacao, so that the yield of copra plus the yield of cacao, in relation to the costs of production and marketing, will convert an uneconomic area into one that is economic. Careful consideration must be given to any proposal to interplant uneconomic coco-nut areas. Land that is obviously unsuited for coco-nuts, that is, heavy impervious soil, water-logged soil, eroded hill-sides, &c., is equally unsuitable for cacao, and should never have been planted with coco-nuts in the first instance. On the other hand, where the decline in coco-nut production may be due to the age of the palms, or repeated insect attacks, or too wide spacing in relation to the fertility of the soil, interplanting would probably provide the difference between profit and loss. The income derived from such an area, over and above the cost of maintenance and interest, could be used to improve the rest of the estate by cultivation and manuring, or for future expansion.

The question as to whether coco-nuts should be interplanted because the ground flora is dense Kunai, opens an avenue for a great deal of discussion. Kunai, which is considered one of the worst plantation pests in the Eastern tropics, has a detrimental effect on all permanent crops, and, in this Territory, it is most noticeable on coco-nuts. The elimination, or even partial control of Kunai would materially benefit the coco-nuts, and its replacement by cacao would mean the substitution of an economic crop capable of producing revenue, and improvement in the physical condition of the soil by the cultivation required to establish the cacao.

The ultimate effect on the soil fertility of two permanent crops, growing in combination on land which for years has supported a dense growth of Kunai, cannot be accurately gauged without the aid of experimental research, and any statement in regard to soil effect must, at the present juncture, remain one of conjecture based purely on observations. From observations made by the writer in various parts of the Territory, where coco-nuts have been interplanted with cacao for periods ranging from two years up to twenty-three years, it is believed that economic returns are possible for a limited period only, and such returns depend on the existing age of the coco-nuts at the time of interplanting, the locality, and the soil origin.

The eradication or control of Kunai can be successfully accomplished by the use of erect, shrubby plants, or creeping cover plants, and species belonging to the order *Leguminosae* improve the fertility of the soil. Where the locality and physical condition of the soil is suitable for cacao, the problem facing the planter whose estate supports a dense growth of Kunai, is whether to control the Kunai by interplanting with cacao, the future effect of which cannot be gauged, or control the Kunai by leguminous plants which are known to benefit the soil.

In instances where the estate is small and yielding a small profit, and no more land is available for alienation, interplanting is wholly justified and a system of sectional interplanting is worthy of consideration.

During the years of depression planters throughout New Guinea suffered considerably from the low prices, and, although other crops such as cacao, coffee, rubber, &c., were equally low in market price, nevertheless, a narrow margin of economic safety was established on those few plantations where there was a small cacao crop in addition to copra. Where cacao is interplanted, and the necessity for weed and grass control considerably reduced, labour units previously employed in grass cutting gangs become available for the cacao, and no marked increase in the normal plantation strength is needed, hence the revenue derived from the cacao is nearly all profit.

For centuries primitive races have followed a system of crop diversification in their food gardens, with the object of minimizing losses due to adverse seasons. In civilized countries where monetary returns are of primary importance, systems combining agricultural crops only, or agriculture and stock-raising are in vogue. Thus, in temperate climates will be seen orcharding and market gardening, or wheat and sheep. In instances where diversification is pastoral the object is the same, namely, to provide some source of revenue should the main crop fail.

In tropical countries, a system of crop diversification is an essential feature of any agricultural policy, and the inauguration of some system in New Guinea is of primary importance to provide some measure of safety should another economic depression occur, or some factor arise which is likely to jeopardize the coco-nut industry. The suggestion is made that consideration be given to the establishment of other crops in conjunction with coconuts, and should economic or other reasons preclude the establishment of a small sole area within the estate, then interplanting would be justified.

In many countries, long-term permanent crops are established and brought into bearing by means of a quick growing catch crop. Thus in Java, coffee is used as a catch crop in rubber. Coco-nuts generally take about ten years to reach the stage where they produce an economic return, and, as cacao commences bearing in the third to fourth year and should be yielding a good return towards the end of the fifth year, it is worth considering as a catch crop to be cut out when the coco-nuts are in full bearing.

There are two factors associated with cacao as a catch crop which require attention. First, proper provision must be made for permanent top shade when the temporary shade has fulfilled its duty after eighteen months to two years, and secondly, the shade needed for the cacao tends to cause "legginess" in the coco-nuts. The writer interplanted twelve to eighteen months old coco-nuts in a manner similar to that usually adopted on estates, that is, adequate provision was made for temporary shade, but no shade of a permanent nature was planted. At the present time the coco-nuts are three and a half to four years old and the cacao two and a

half years old; the coco-nuts show a marked tendency to "legginess", and, although the cacao made excellent growth during the first two years, it is now in the generally poor condition as shown by Table No. 6.

TABLE No. 6.

Original Number Seedlings.	Dead.	Healthy and Bearing.	Unhealthy and Bearing.	Healthy non-Bearing.	Severe Die-back.	Slight Die-back.
210	16	6	10	14	120	44

The "legginess" in the coco-nuts may be attributed to the shade being planted in full rows close to the coco-nuts, hence normal trimming did not prevent over-shadowing, and the poor condition of the cacao is entirely due to the lack of sufficient top shade when the trees became fairly large and the temporary shade commenced to die through age.

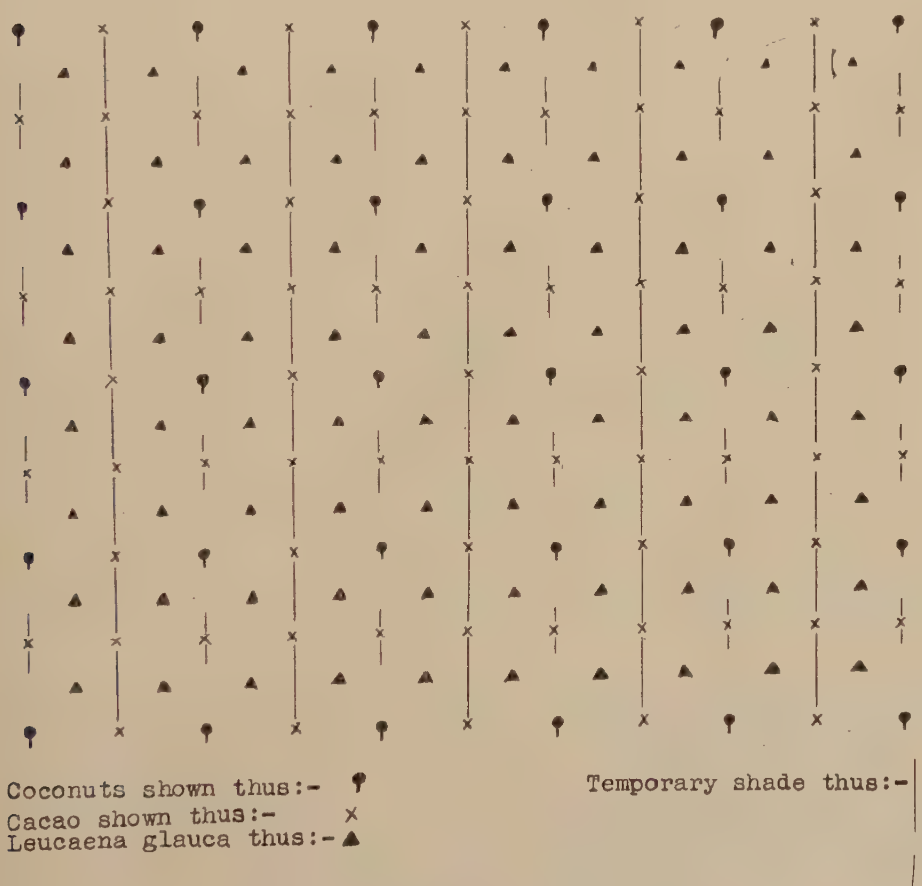


Figure No. 6.—Coconuts planted on the square system.

Should interplanting be necessary for some of the reasons outlined, then it is suggested that a lay-out as shown in these diagrams is worthy of adoption.

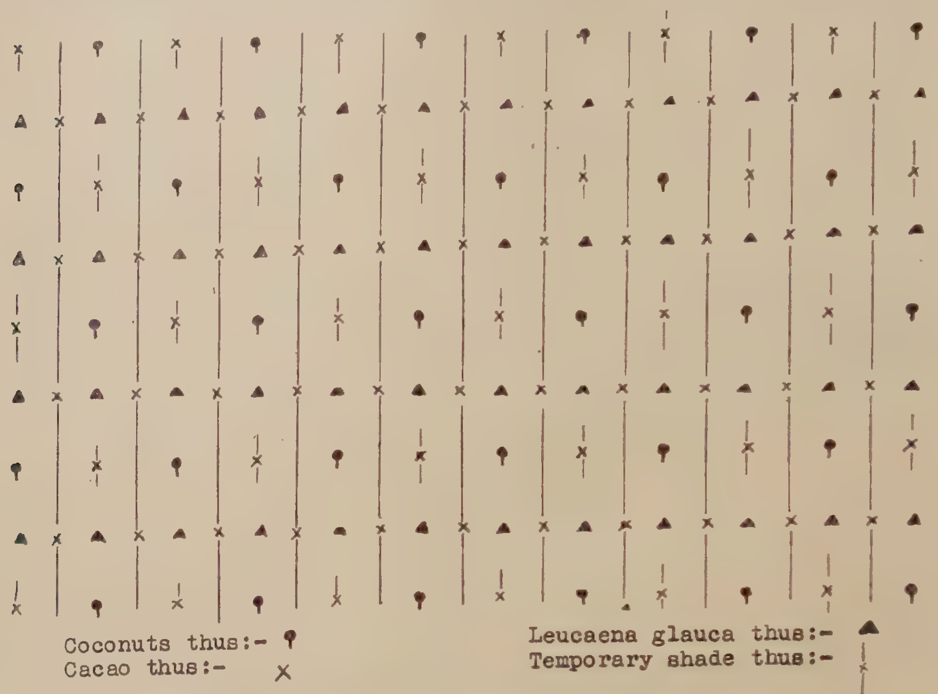


Figure No. 7.—Coconuts planted on the equilateral triangle system.

The foregoing lay-outs are adapted for permanently interplanting large palms. The permanent shade of *Leucaena glauca* is heavy, but this is intentional, as the planter will have to regulate the shade to suit local conditions of soil, climate, and coco-nut growth, and it is preferable and easier to reduce shade than it is to increase it, if insufficient. Fig. No. 6 (square system) allows for alternate shade trees in alternate rows to be cut out, and Fig. No. 7 (equilateral triangle system) allows for alternate trees only to be cut out. When interplanting as a catch crop in young coco-nuts, the permanent shade should be reduced to about 50 per cent. of what is shown for the old palms.

Tephrosia candida, or a 60/40 mixture of *Tephrosia candida* and *Crotalaria anagyroides* is recommended as temporary shade.

Systems of Lining.

The usual system of lining is that known as the "square", although another system known as the "equilateral triangle" has a great deal to recommend it, and it is considered that this system is superior to the "square" system.

It is often stated that the "square" is used because it is easy to lay out, but the writer opines that the "equilateral triangle" is just as easy, besides having the advantage of allowing more trees per acre (approximately 15 per cent.), and, as each tree is surrounded by six others equidistant from it, the tendency is towards greater uniformity in shape.

Should a prismatic compass or some other instrument suitable for the purpose be unavailable, when it is necessary to lay out a right angle in the field, then the simple 3, 4, 5 formula can be used in the following manner, using Figure No. 8 as an illustration.

Suppose the line A B is the base line from which at a point C it is desired to run another line C D at right angles. Mark along A B from C towards B a point Y four yards from C, then along the proposed C D line a point X three yards from C. The line X Y should measure exactly five yards if the angle at C is to be a right angle. If not, then move the point X until X and Y are five yards apart and X and C still three yards apart. Thus if X C is three yards long, C Y four yards long, and X Y five yards long the angle at C is a right angle and a line produced through X from C is at right angles to A B.

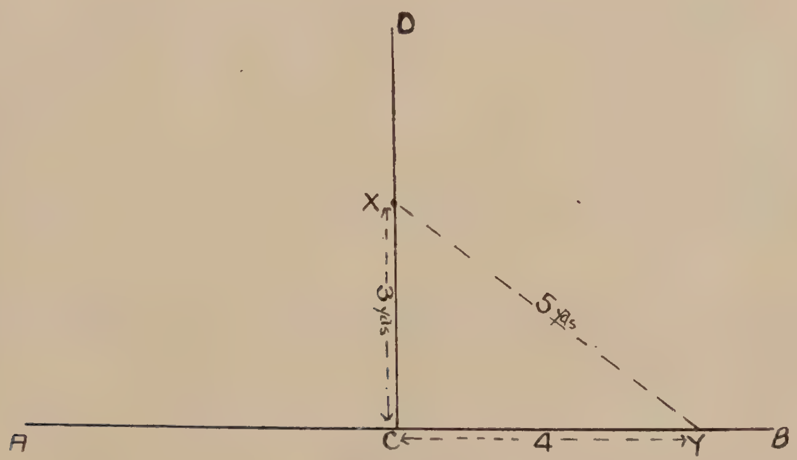


Figure No. 8.

Lay-out for "Square" System.

Take a piece of land A B C D as shown in Fig. No. 8A. Mark off a suitable base line E F and at a point G a line G H is offset at right angles. Should no instruments be available then the 3, 4, 5 formula just described can be used for setting out the right angle.

The line G F is now marked according to the distance apart required and stakes inserted at the points a, b, c, d, e, &c.; the line G H is then marked in a corresponding manner and stakes inserted at the points 1, 2, 3, 4, 5, &c.

Another right angle is now laid off at the point a on the line G F and the line a K is marked in the same manner as G H, stakes being inserted at the points b, c, d, e, &c. There are now two parallel lines at right angles to G F, and lining is continued by sighting through the two stakes 1, and b, and marking the line 1, b, c, d, &c., then through 2, and c; 3, and d; and so on until complete.

Once two or three lines have been completed, if so desired, lining can be carried out either horizontally or vertically to the base line. Lining is expedited by stretching along the line a wire or tape marked at the requisite distances (rope

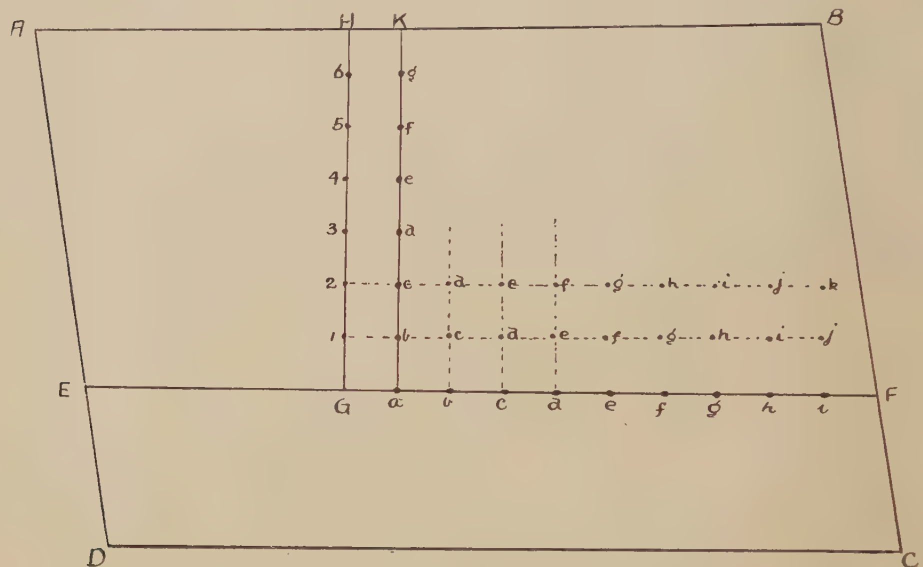


Figure No. 8A.

should be avoided for this purpose as it tends to stretch too much). At least three labourers are necessary, one at each extremity of the wire or tape, and one to place the stakes in position.

Lay-out for "Equilateral Triangle" System.

Take a piece of land A B C D as shown in Figure No. 9.

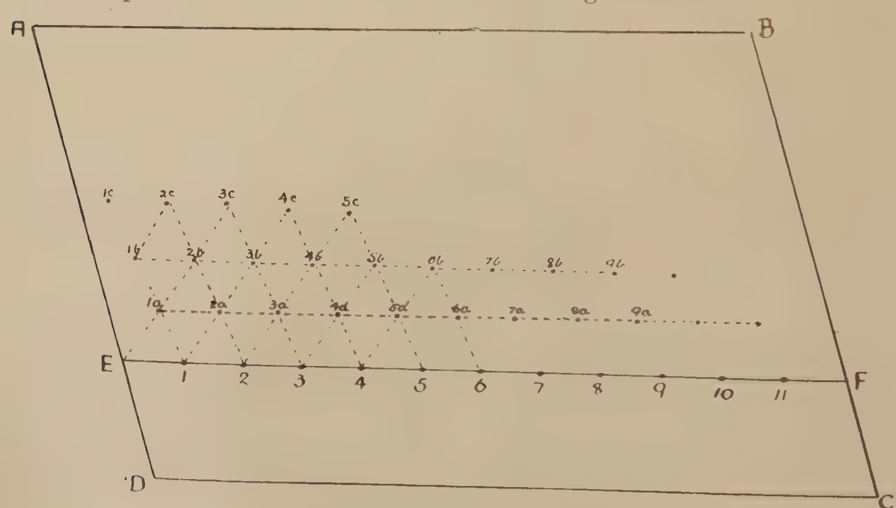


Figure No. 9.

Mark a suitable base line E F and insert stakes along it at the distance apart it is required to plant, moving from E through 1, 2, 3, 4, 5, &c.

Take a piece of flexible wire, attach a ring to each end and one ring in the centre so that the overall length of the wire is double the planting distance. For example, if the planting distance is 15 feet the length of the wire from outside ring to outside ring is 30 feet, as shown in Figure No. 10.

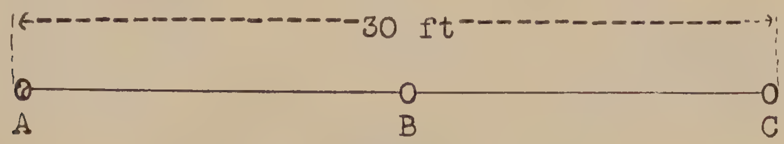


Figure No. 10.

Place the end ring A at E, and the other ring C at 1, tighten the wire by grasping the centre ring B and insert stake through the ring at 1a (Fig. No. 9), then move along E F, placing ring A at 1, and ring C at 2, tighten the wire and insert stake at 2a, and continue until the base line E F has been traversed and the line 1a, 2a, 3a, 4a, &c., marked. The line 1b, 2b, 3b, &c., is lined in a similar manner except that the first stake inserted is at 2b, and the position of 1b is found by keeping ring A at 1a, and moving ring C to 2b. Lining of the area can proceed as requisite and it is not necessary to return to the E end of the land each time, but work backwards from the last two stakes on the line just completed.

When the area enclosed by the lines A B E F is finished the same line E F is used for marking the area enclosed by E F D C.

It should be noted that a fixed bamboo or light wooden triangle with each side equal to the desired planting distance, may be used instead of the single wire as described and illustrated.

To ascertain the number of stakes required, or the number of seedlings per acre, the following formulae may be used:—

N = number of stakes or seedlings.

"Square system"

$$N = \frac{43560}{\text{square of planting distance (in feet)}}$$

e.g. planting distance is 15 ft. x 15 ft.

$$\therefore N = \frac{43560}{15 \times 15} = 193$$

"Equilateral Triangle system"

$$N = \frac{43560}{\text{square of side of triangle (in feet)}} \times 1.155$$

e.g. planting distance is 15 feet.

$$\therefore N = \frac{43560}{15 \times 15} \times 1.155 = 222$$

Variety to Plant.

It is obvious that the variety to plant will be that species which produces the best quality and at the same time yields a sufficient quantity for economic cultivation. The type to be preferred from the aspect of quality is Criollo, but this "fine" variety requires a particular soil and climate, careful cultivation, is susceptible to disease, and, unless conditions are ideal, does not yield heavily. Theoretically then, the species to be cultivated in New Guinea should genetically contain, as closely as possible, the attributes of Criollo, but without that specialization in respect to soil and climate, susceptibility to disease, and propensity towards low yield.

Practically, however, from the view point of economic production, it must be remembered that English and Continental manufacturers of cacao products have, in recent years, developed the technique of manufacture to such a degree that a high class article can now be evolved from "ordinary" cacao. Further, the recent world-wide economic depression materially affected the purchasing power of the general public, with the result that, as the demand for high grade, high-priced chocolate decreased, there was a corresponding increase in the demand for the medium and lower-priced articles.

Australia, which presumably will be the market, at present imports annually a large quantity of "ordinary" and "fine" cacao. The former from West Africa, and the latter from the West Indies, Java and Ceylon. It has already been mentioned that manufacturing technique has reached a high degree in recent years and it is quite within the bounds of possibility that, in the near future, less "fine" cacao will be required. To guard against this contingency it will be necessary to cultivate that species producing a cacao superior to "ordinary" cacao, and having a yield sufficiently high to successfully compete with the "ordinary" type from the aspect of cost of production in relationship to market price.

The small area of New Guinea cacao at present under cultivation belongs to the Trinitario group, which, according to Cheesman,[5] "consists entirely of hybrid forms, from which any type can be selected from something near Criollo to something almost pure *Th.leiocarpa*".

In discussing the complexity of constitution of the Trinitario group, Cheesman[5] cites Van Buren,[3] who described and classified a progeny of 609 trees from a single parent tree which was described as a "*Forastero Cundeamor*", a heavy yielder containing white as well as purple seeds in the pods. Van Buren's classification was as follows:—

Angoletas	194
Cundeamor	357
Amelonado	58
	609

The cacaos of Eastern Venezuela, Trinidad, Grenada, Costa Rica, Ceylon and Java belong to the Trinitario group, which constitutes about twenty per cent. of the world's output.[5]

The Venezuelan Trinitario consists of the finest Angoleta and Cundeamor types through to Amelonado and Calabacillo(12), and the same applies to the Trinidad Trinitario.(5) In Java, the Djati Roenggo hybrids, which form the bulk of the cultivation, are the result of crossing a single cundeamor plant, introduced from Venezuela in 1888 with the local Criollo. The entrance of what is known as Java Criollo is unrecorded, but it is supposed to have travelled from Ceylon, where it was introduced via Trinidad about 1934, and became known as the "Old Red" variety.

The history of New Guinea cacao tends to show that it came from Ceylon and Java by way of Samoa. Van Hall(12) states that Criollo cacao was introduced into Samoa from Ceylon and Java in 1883, and later, in 1889, Forastero hybrids were imported from Ceylon. After the annexation of New Guinea by Germany in 1884, large numbers of natives were sent to Western Samoa as plantation labourers, with the result that by 1900 shipping communications between the two colonies had become well established. The largest company operating in New Guinea during this period had its head-quarters in Samoa, and was establishing cacao estates in the latter country. Therefore, there is every likelihood that the operations of this company were responsible for the introduction of cacao into New Guinea, and that the planting material was brought by the transport required for the recruitment and repatriation of the labourers. Furthermore, the first recorded cacao exports of any importance from both Samoa and New Guinea occurred in the year 1905. From the foregoing paragraphs it will be seen that the cacao in New Guinea is linked through Samoa with Java, Ceylon, Trinidad and Venezuela. This correlation being further substantiated by certain Australian manufacturers who state that the New Guinea beans are similar to the beans of the West Indies, Java and Ceylon.

From the writer's experience of cacao, he opines that the material available in this Territory is superior to that of Trinidad, and at least equal to that of Java. Further, there are a small number of pure Criollo trees in the Botanic Gardens, Rabaul, that are available for breeding purposes.

Bearing in mind the varietal complexity of the Trinitario group, *it is essential that before establishing a large-scale industry in New Guinea, a thorough investigation be made of all the available planting material,* and mother trees for seed supply should be selected throughout the Territory wherever cacao is under cultivation. Excellent primary material is available in New Guinea, and the importance of seed selection, together with a policy of breeding and future improvement cannot be too strongly stressed.

Distance to Plant.

The spacing of cacao differs in various countries, and depends mainly upon local soil conditions, shade used, type cultivated, and climatic conditions which govern the size and growth of the tree. Where the soil is fertile, the spacing should be wider than on poor soil in order to allow for the expansion of the tree, and, if no shade is used, then the distance should be close. For example, in Grenada, where shade has not been planted, the cacao distance is 9 feet by 9 feet.

Experiments carried out at River Estate, Trinidad, with trees planted 6 feet by 6 feet, 8 feet by 8 feet, 10 feet by 10 feet, 12 feet by 12 feet, 14 feet by 14 feet, 16 feet by 16 feet, 18 feet by 18 feet, show that the trees planted at the

closed distance of 12 feet by 12 feet gave the highest yield from the fourth to the tenth year, but from the eleventh year onwards, the trees at 14 feet by 14 feet surpassed the yield of those at the closer planting, with the result that the total production at the end of eleven years was identically the same.[12] In 1934 those planted 16 feet by 16 feet, were yielding more than the 12 feet by 12 feet, or the 14 feet by 14 feet.

In certain areas of some cacao growing countries, where the young seedlings grow easily and do not require much attention, they are closely planted,[12] the reason for this system being that there are more trees to harvest during the first few years of production, and they very quickly shade the soil. The system has its advantages, but the superfluous trees must be thinned at the correct time, otherwise those which have to remain permanently will have adapted their leaf and branch system to their confined space and will not acquire their correct form, with the result that future production is definitely impaired. Unless the planter is prepared to thin out when the time comes, and it is known that the cacao grows easily, the system is not to be recommended.

Generally speaking, the usual planting distance in most countries varies from 12 feet to 17 feet. So far as New Guinea is concerned, the distance selected will depend on local conditions of soil and climate. The writer, however, considers that, until the results are available from distance experiments already commenced at the Demonstration Plantation, Keravat, 15 feet by 15 feet is quite suitable for general adoption.

Planting of Windbreaks.

The cacao tree is very susceptible to wind effects, and protection from prevailing winds is essential if the cultivation is to become an economic proposition.

It has already been pointed out that the utilization of strips of natural forest is not advisable, and that the cultivation of more adapted trees is to be preferred. No hard and fast rule, however, can be laid down in respect to the width and distance apart of the windbreaks throughout the estate, as the strength of the prevailing winds varies in different localities.

Many trees are recommended by various authorities, and the following may be mentioned:—*Mangifera indica* (Mango), *Peltophorum inerme* (Peltophorum), *Cedrela odorata* (Cedar), *Pithecolobium saman* (Saman or Rain Tree), *Tamarindus indica* (Tamarind), *Artocarpus integrifolia* (Jak Fruit). There are also certain indigenous trees such as *Canarium* spp. (Galip), and *Pterocarpus indicus* (Rosewood or New Guinea Teak), which would provide useful windbreaks.

Should slow-growing trees such as *Mangifera indica* be selected, then several years must elapse before the duty of an efficient windbreak is being fulfilled, and it is recommended that quick-growing trees such as *Leucaena glauca* or *Erythrina lithosperma* be planted to serve as temporary windbreaks. Annatto (*Bixa orellana*) is also useful, and bamboo along creek or river banks is invaluable, both as a windbreak and in the control of erosion.

Some species have a tendency to lose their lower branches as they mature, and, in this case, it is advisable to inter-plant a low-growing type of tree to afford protection from ground level up to the lower branches of the large tree.

In the writer's opinion, consideration should be given, when establishing windbreaks, to species that have some economic value, and, where possible, indigenous rather than exotic trees should be used.

Methods of Planting.

There are two methods of planting which may be adopted, namely:—

(1) Planting at stake.
(2) Nursery.

1. *Planting at Stake.*

This system has been used in many countries, and was the main system adopted when establishing the cacao industry in Trinidad.[9] It is very simple, four seeds are planted in the form of a rectangle or square at the base of the "lining" stake, and when the plants are well above ground, the weakest are removed, allowing the strongest one to remain. In localities where diseases and pests are not troublesome this method may be used with success, but where enemies are present control measures become difficult. When compared with the nursery system there are many disadvantages; selection is limited, the seedlings do not grow so well as those transplanted at the correct period of the year, i.e. the commencement of the wet season, four times the quantity of seed is required, and there is the likelihood of damage occurring to the remaining seedling when the other three are removed. The question of pest and disease occurrence on cacao seedlings has yet to be thoroughly investigated in New Guinea, and this factor, plus the disadvantages already outlined, tends to preclude for the present planting at stake unless absolutely necessary. It should be mentioned, however, that this aspect of planting is under consideration by the Department of Agriculture, and at the Demonstration Plantation, Keravat, an area has already been laid down for experimental purposes.

2. *Nursery System.*

The site selected for the nursery should be close to the area to be planted, also to water, and if bamboo pots or baskets are not used, then the soil should be fertile to permit strong development of roots, stem and leaves.

Shade is necessary for the nursery, and this may be accomplished artificially in the following manner:—Strong posts are sunk in the ground at convenient distances apart, in order to support a temporary roof of palm leaves at a height of approximately 7 feet above ground level.

The soil is thoroughly turned over by means of a hoe or fork, and worked into a fine tilth, care being taken to remove any stones or roots that are liable to interfere with the development of the young seedling. The presence of any hard substance such as stones, or roots in the soil, easily and quickly causes a physiological condition known as "bench rooting", i.e. the roots become distorted. Van Hall[12] is of the opinion that a heavy soil is to be preferred to a light one, because of the capacity of the former to adhere to the roots, thereby allowing for a ball of soil when the plants are transferred to the field. The writer has seen instances of "bench rooting" occurring in the heavier soils of the Territory, and considers that heavy soils such as are found on the Island of New Hanover, for instance, should be mixed with sand and compost to make them suitable for nursery conditions.

Narrow beds, 3 feet to 4 feet wide and raised at least 6 inches above ground are now made, and each bed should be separated by a pathway one to two feet wide in order to facilitate watering, weeding, spraying (if necessary), and removal of the plants for transplanting purposes.

The seed is normally planted in rows 1 foot apart, and 1 foot distant in the rows, but if it is proposed to remove the seedlings when quite small, then the distance apart in the rows can be reduced to 9 inches. The seed should always be planted with the hilum or scar end downwards or sideways in the soil, never upwards otherwise the seedlings are distorted and germination impaired; the depth of planting is 1 to 2 inches below ground.[10]

The use of pen manure or compost is beneficial; the first application should be made when the soil is primarily forked, and a further application, when the plants have reached a height of 6 inches to 8 inches.

Should dry weather be experienced then watering is essential, and, prior to transplanting, it is advisable to thin out the shade to some extent in order to accustom the plants to field conditions, although, when palm leaves are used as a covering over the nursery, they automatically reduce the shade as they dry. The seedlings are ready for transference to the field after a period of four to five months, when they have attained a height of 12 inches to 18 inches, and have at least five permanent leaves. The plant holes should be dug at least two to three months in advance of transplanting.

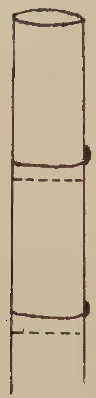


Figure No. 11A.

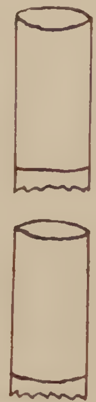


Figure No. 11B.

The use of bamboo pots or baskets is often preferred, because transportation to the field can be accomplished without danger of injury to the plants, and, also, the necessity for having the nursery close to water is not so essential. For New Guinea, where the labourers tend to be untrustworthy, the utilization of bamboo pots or baskets is recommended.

Bamboo pots are constructed by taking lengths of bamboo, and cutting off immediately below the node, Fig. No. 11 (A), so that a complete section open at one end, and closed at the other, is made, Fig. No. 11 (B).

After cutting, a small drainage hole is made in the closed end of the pot, and it is filled with soil; pure compost makes an excellent media for cacao germination, and after growth of the seedlings, should compost not be available, then use, as far as possible, a soil rich in organic matter; the top soil taken from underneath the temporary shade in the field gives results commensurate with compost.

When the seedlings are ready for transplanting, the pot is well watered and transported to the planting hole, where it is split longitudinally, the sides removed, and the young seedling planted with the soil adhering to the roots. Should

baskets, which are made of plaited palm leaf be used, then the seedling is not removed, but planted basket and all. The basket method is very simple, allows for the young plant remaining undisturbed, and the basket soon rots in the soil; the disadvantages, however, are that the baskets are liable to attract white ants which may damage the young plants,[12] and, where bamboo is plentiful, the pots are cheaper (a labourer will make about 600 bamboo pots per day if the bamboo is supplied to him).

When transplanting, it is advisable to adhere as closely as possible to the following general principles:—

1. Care should be taken when removing the seedlings from the nursery that the root system is not damaged, and that a large ball of earth is allowed to remain attached to the roots, and covered with a piece of banana leaf or some other material. This may easily be managed, if the nursery is watered just prior to removal.

2. If the nursery soil is very loose then wash the roots with water, loosely place the plants in bundles, and keep the roots wet during transportation.

Plate No. 9.

Plate No. 9.—Illustrates a nursery, showing the manner in which the palm leaf roof automatically "hardens-off" the seedlings as it dries.

3. Transplant in the early morning or late afternoon, or during a cloudy or drizzly day; never when the sun is hot during mid-day.

4. Transport carefully to the field to avoid undue shaking.

5. If the seedlings are large, then reduce some of the leaves to prevent excess transpiration.

6. After transplanting into the field, cover the seedlings with palm leaves or some suitable medium, and allow the covering to remain until the plants have struck.

7. Do not plant too deeply; place the seedlings the same height above ground as they were in the nursery.

8. When filling the holes, place the best soil in the bottom of the hole, around the roots.

Estate Management After Establishment.

Weeding.

The weed and grass growth may be divided into two sections—(1) detrimental, and (2) non-detrimental. *Imperata arundinacea* (kunai, blady grass or lalang), *Paspalum conjugatum* (thurston grass), and *Chrysopogon aciculatus* (seedy or love grass) should not be allowed in the cacao fields; they form a dense mat which interferes with soil aeration, thereby retarding the activities of soil organisms and movement of soil moisture. On the other hand, soft weeds such as species of *Amaranthus,* may be termed non-detrimental, particularly if cut before seeding, when a large amount of nutrient that has been gathered from the soil is secreted in the tissues, and is, therefore, returned to the soil to become re-available.

The extent of the weeding will depend to a large extent on the planter and his finances. "Clean weeding" is recommended by many authorities and, when compared with "permanent weeding" i.e. continual grass control, shows to advantage as cultivation costs are lowered and the soil is maintained in good tilth. The writer considers that the utilization of leguminous creeping ground covers such as *Dolichos hosei,* or *Desmodium scorpiurus* is even preferable to clean weeding as cultivation costs are further reduced, the soil is protected from erosion, and a great deal of humic material is being continually added to the soil.

Maintenance of Soil Fertility.

Recent experiments carried out in Trinidad[22] have shown that in poor cacao soils there is a lack of nutrient balance. Phosphate particularly, and potash in some cases are deficient, and, so far as nitrogen is concerned, the results obtained tend to show that indiscriminate nitrogenous manuring may be harmful unless phosphate and potash deficiencies are first remedied.

No investigational work has been carried out in regard to the nutrient status of the New Guinea soils except in a few instances by the unsatisfactory method of trial and error, and it is impossible to arrive at any conclusion as to the amount of phosphate or potash present. It is, however, recognized that green manure plants absorb phosphate and potash from the soil for their own benefit,[20] and that to obtain the maximum amount of nutrient to be returned to the soil by the growth of a green manure plant, it is essential that it be pruned and the green material turned in from time to time. In this way, the phosphate and potash held by the plant will become re-available in the soil. Therefore, it is considered that the judicious planting of leguminous crops at the commencement of cultivation, and correct management of these crops should tend to maintain fertility until facilities become available for a full investigation of the soil nutrients.

The soils derived from pumice and volcanic ash in the Gazelle peninsula of New Britain, tend to quickly lose their fertility once the virgin bush is felled, and it is essential that some soil protecting crop be planted immediately following clearing, and maintained throughout the whole period that the cacao is under cultivation.

It is suggested that all prunings and loppings should be trenched in the following manner, providing the soil is not too heavy. Shallow trenches are dug down the centre of alternate rows in alternate years, running longitudinally for two years, and laterally for two years, and in this way a four-year rotation of trenching is developed throughout the estate.

Where weeding is practised, the material can be collected and "composted", i.e. stacked in moderately long, narrow heaps about 3 to 4 feet high and allowed to rot, the heaps being turned every three to four weeks to facilitate aeration and bacterial activity. Under fairly heavy rainfall conditions the heaps should rot down in three to four months, even if no activator such as animal urine, night soil, cattle manure or sulphate of ammonia is used. This system of handling weed and grass growth is being used with success at the Demonstration Plantation, Keravat, where a small quantity of previously made compost is used for activating new heaps.

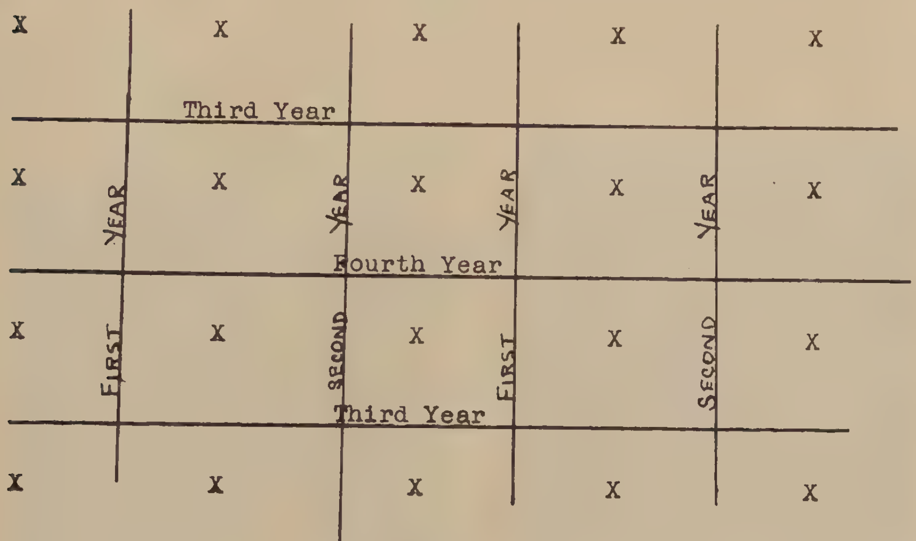


Figure No. 12.

Cultivation.

Tillage increases the uniformity of the soil and, generally speaking, is beneficial. Bacteria, particularly the nitrifying type, should multiply when free access of air is increased; cultivation also assists in keeping the soil sweet and allows for a more rapid conversion of the green material, resultant from pruning and lopping, into humus.

If, however, forking or hoeing is practised, care should be taken not to cultivate too deeply, or too closely to the base of the tree otherwise the feeding roots are severed or damaged in such a way as to retard growth and cropping. It is advisable then, that a space be allowed to remain untouched around the base of the tree, and the operation carried out towards the end of the wet season so that the tree has the opportunity of restoring its root system before the onset of the dry season. One authority[12] recommends that the practice of "alternate forking", i.e. tilling of every other space in a row, be adopted in areas where the dry season is rigorous and prolonged; it is considered, however, that this practice should not be necessary in many parts of New Guinea, as the rainfall appears to be quite sufficient during the drier period of the year. Where *Dolichos hosei* or *Desmodium scorpiurus* is used as a ground cover, it may be turned in from time to time, alternate rows at each turning, and not buried too deeply.

Pruning.

The aim of this operation is to modify the growth of the tree by removing all unnecessary branches, twigs and shoots in order to obtain a regular conformation.

When pruning, all water shoots and suckers, dead or diseased branches or twigs, non-bearing branches, and branches or twigs interfering with the well-shaped canopy of the tree are removed. The ends of the lateral branches which are running out and will not produce pods, are cut back to the nearest strong growing subsidiary branch which is growing upwards and outwards, and not inwards towards the centre of the tree. All secondary branches and twigs growing from the laterals inwards are removed, or cut back to smaller growing twigs which are strong and healthy.

On account of the rapid growth of water shoots and suckers especially under the conditions prevailing in New Guinea, every endeavour should be made to remove them at least two to three times per year, at the same time removing any diseased or dead branches or twigs.

Plate No. 10.

Plate No. 11.

Plate No. 10.—Illustrates young cacao growing under the correct density of shade.
Plate No. 11.—Illustrates the effect on young cacao when the shade is too dense.

The tree should not be allowed to develop secondary and tertiary ramifications, and it is advisable to maintain the tree at such a height that picking, and pest and disease control is made easy. Theoretically, the correct period of the year to prune, is when the tree is resting, i.e. the dry season, but experience in this Territory has shown that the tendency is for the tree to bear throughout the whole year, hence, a certain amount of pruning is essential at all times.

During the period that the young seedling is growing, all water shoots and ground suckers, which absorb a large amount of nutrients, should be removed, and, as far as possible not allowed to grow so that they cannot be "thumbed off", i.e. brushed off with the thumb and fingers. From the beginning it is advisable that an endeavour be made to evolve a tree which, when mature, has a good canopy, and the crown is such that there is no interference with the suitable penetration of light and air.

As a general rule, there should only be three or four primary branches allowed on the tree, and these should be encouraged to grow outwards and upwards. The secondary and tertiary branches should be allowed to develop at regular intervals. Every endeavour must be made to keep the tree balanced, so that a lop-sided effect is not produced by having certain branches growing more rapidly.

When pruning, make all cuts on an angle so that rain water is shed, and treat the larger wounds with coal tar followed by a little sand or earth, or some other antiseptic dressing. Bush knives or cacao hooks should not be used for pruning; proper pruning knives attached to a rod and fitted with a lever are needed for the upper parts of the tree, and secateurs for the small lower branches and twigs. All large branches should be sawn, and it is advisable to make the first cut about 1 foot above the required position, then later cut off at the correct place.

Plate No. 12.

Plate No. 13.

Plate No. 12.—Illustrates a well grown two year old tree before pruning.
Plate No. 13.—Illustrates the tree shown in the previous plate after the initial pruning.

A contributing factor regarding the future height of the tree is that of shade, which if too dense results in high ramification of the cacao, and, if too light, then low. The most desirable height for ramification is approximately 3 ft. 6 in. above ground level.

Rejuvenation.

Where a tree becomes barren or worn out it may be rejuvenated provided, of course, that the rooting system is sound. A number of "chupons" or suckers are allowed to come away from the base as close to ground level as possible, as they grow the number is gradually reduced until only the strongest one remains. This "chupon", which will eventually replace the parent, is now treated in the same manner as a seedling.

During the growth of the "chupons", the parent tree should be gradually reduced until only the stump remains, when the single "chupon" is left. As the larger branches of the parent are removed, the cut surface should be treated with coal tar and earth, or some other antiseptic dressing.

Picking and Breaking.

Once the cacao trees have commenced bearing, they must be harvested and the product prepared for market. The ripening of the pods is indicated by a change in colour, and as knowledge of the correct stage of picking can only be gained by experience, it is essential that special labourers should be trained to perform this skilled operation. A pod that is red or green when unripe, changes to a lighter or darker red, reddish yellow, or yellow when ripe, and one that when unripe is red-green, turns reddish yellow when mature. Furthermore, the seeds in a ripe pod adhere to the "placenta" of central core only, and, if the fruit is shaken, the seeds can be heard moving against the inside of the husk; also, if the outside of the pod is tapped with the fingers, a hollow sound results.

It is necessary that care be taken when removing the fruit that only mature pods are harvested, and a clean cut of the stem of the pod made in order not to injure the cushion. The pod should not be cut off too near the cushion, and the jointed portion of the pod stem left attached to the tree; the reason for this, is, that healing of the wound is quicker, and there is less danger of fungal infection. The necessity for careful harvesting cannot be too strongly stressed, damage to the cushion results in reduction of crop and possible ingress of disease organisms. Unripe beans produce an inferior grade of cacao [19] which cannot be remedied by curing, whilst over-ripe beans have commenced to germinate and when dry, there is a small aperture in the end of the bean for insect pests to enter.

Once the crop season commences, the picking gang should be sent frequently into the fields in order to reduce the harvesting of unripe or over-ripe pods. The implement generally used for the removal of the higher pods is known as a cacao hook, and is attached to a length of bamboo; in New Guinea it would be preferable to use a long-handled tree pruner to obviate damage to the cushion by the cacao hook in the hands of an unskilled labourer. The lower pods may be removed by means of a sharp knife or secateurs; if the latter are used, then they must be kept sharp so that the stem is cut without bruising, the knife must also be kept sharp so that the cut is cleanly made.

After picking, the pods should be gathered into heaps preparatory to breaking, which is accomplished by means of a straight or slightly curved knife. Should it be found that, through inexperience, the labourers are cutting the beans at the time of cutting the pod, then the pod may be broken by hitting it with a short stick. After the pods are split open, the contents are removed, and the beans separated from the "placenta" or central core. They are then placed in receptacles suitable for transporting to the fermentation house. It is important that no placenta be mixed with the beans, otherwise fermentation is impaired and the quality of the cured product reduced.

Fermentation.

Should the beans after extraction from the pod be immediately dried, then the resultant product has a tendency to absorb atmospheric moisture, become sticky, and, when in this condition, is quickly susceptible to mould growth. [18] Furthermore, an essential oil which gives the cacao its aroma must be developed, the bitter taste lessened, and, in addition, other changes should occur which assist in

imparting the qualities desired by the manufacturers.[12] Therefore, in order to produce a stable product, which can successfully compete on the market, it is necessary that the mass be subjected to a process known as fermentation.

Fermentation is carried out in a series of containers known as "sweat" boxes, which should be constructed of wood. In some instances, concrete receptacles have been used, but experiments have shown that concrete inhibits the growth of yeasts, bacteria, &c., essential for the process. The size of the boxes and the arrangement of the series, will depend on the amount of crop.

A box measuring 15 feet by 4 feet by 3 feet, divided into three compartments, each 5 feet by 4 feet by 3 feet, would handle about 3,000 lb. of wet cacao in each section. Should a smaller quantity of beans be harvested each picking, then the boxes could be made relatively smaller, remembering that 1 cubic foot of wet beans weighs about 50 lb. A good standard type of box suitable for small crops is one measuring 8 feet by 4 feet by 2 feet, divided into four sections each 4 feet by 2 feet by 2 feet (*see* Figure No. 14).

It is important to know that the depth of beans in the box should not exceed 3 feet, otherwise aeration is impaired, and improper fermentation occurs.

When constructing the boxes, only seasoned timber should be used, otherwise warping, with resulting difficulty in removing the sides, is experienced. The dividing wall between each section should be removable to facilitate transference of the mass from box to box. The ends could also be removable to assist in filling and discharging.

There are various systems in operation regarding the layout of the fermentation boxes. Van Hall[12] describes one in vogue on Djati-Roenggo estate in Central Java, which the writer saw in 1930. In it, the containers are arranged in tiers, the top boxes are filled first, the mass is then transferred to the box below, each day, and from the last box at ground level, the fermented beans are shovelled into the washing basin. This system is easily installed on sloping land, and facilitates handling during fermentation.

Another system is illustrated by the following series of diagrams, which are reproduced with the permission of Mr. J. de Verteuil,[8] and consists of boxes placed side by side at the same elevation. This method is suggested for consideration in preference to the former, from the point of view of simplicity of construction and low initial cost.

The lower walls of the fermentation house are of stout planks or concrete to a height of 4 feet to 5 feet from ground level; if the latter is used, then the inside must be lined with boards otherwise fermentation is retarded. Boarding is continued to within 2 feet of roof, and from here upwards stout wire netting is used. The bottom of the house is concrete with a slight fall towards a gutter, so that the sweatings can flow away (*vide* C and D). The enclosed space for the sweat boxes is divided into two or more compartments by means of removable boards fitted into a groove, and the bottom of the boxes consists of a removable grate in two or more pieces to facilitate cleaning. The grate is constructed of laths $\frac{1}{8}$ inch apart, resting on runners approximately 9 inches above the floor. For the purpose of ventilating the boxes, the walls below the level of the grates are provided with openings about 18 inches wide (*vide* Figure No. 13).

A third system is that shown in Fig. No. 14 and was designed by the writer for small estates or estates coming into production, where the planter need not be under the expense of building an elaborate fermenting house until he is able to gauge his production accurately. Even then, this type of box is easily increased in depth and series.

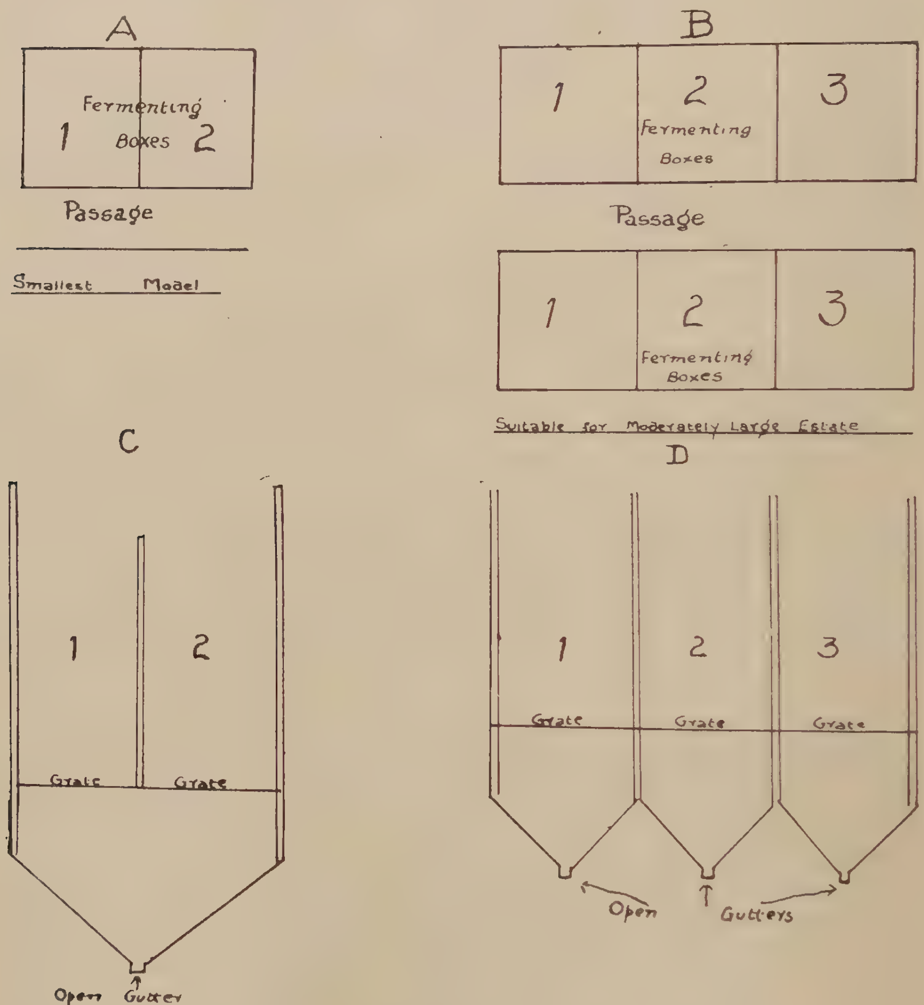


Figure No. 13.

The box measures 8 feet by 4 feet by 2 feet, the sides are fixed, and the ends are removable with internal sliding panels which provide for sectioning within the box itself, so that it may be divided into four compartments, each measuring

4 feet by 2 feet by 2 feet, thereby allowing for a small quantity of beans to be efficiently fermented. Well seasoned hardwood, 12 inches by 1 inch, is used, the

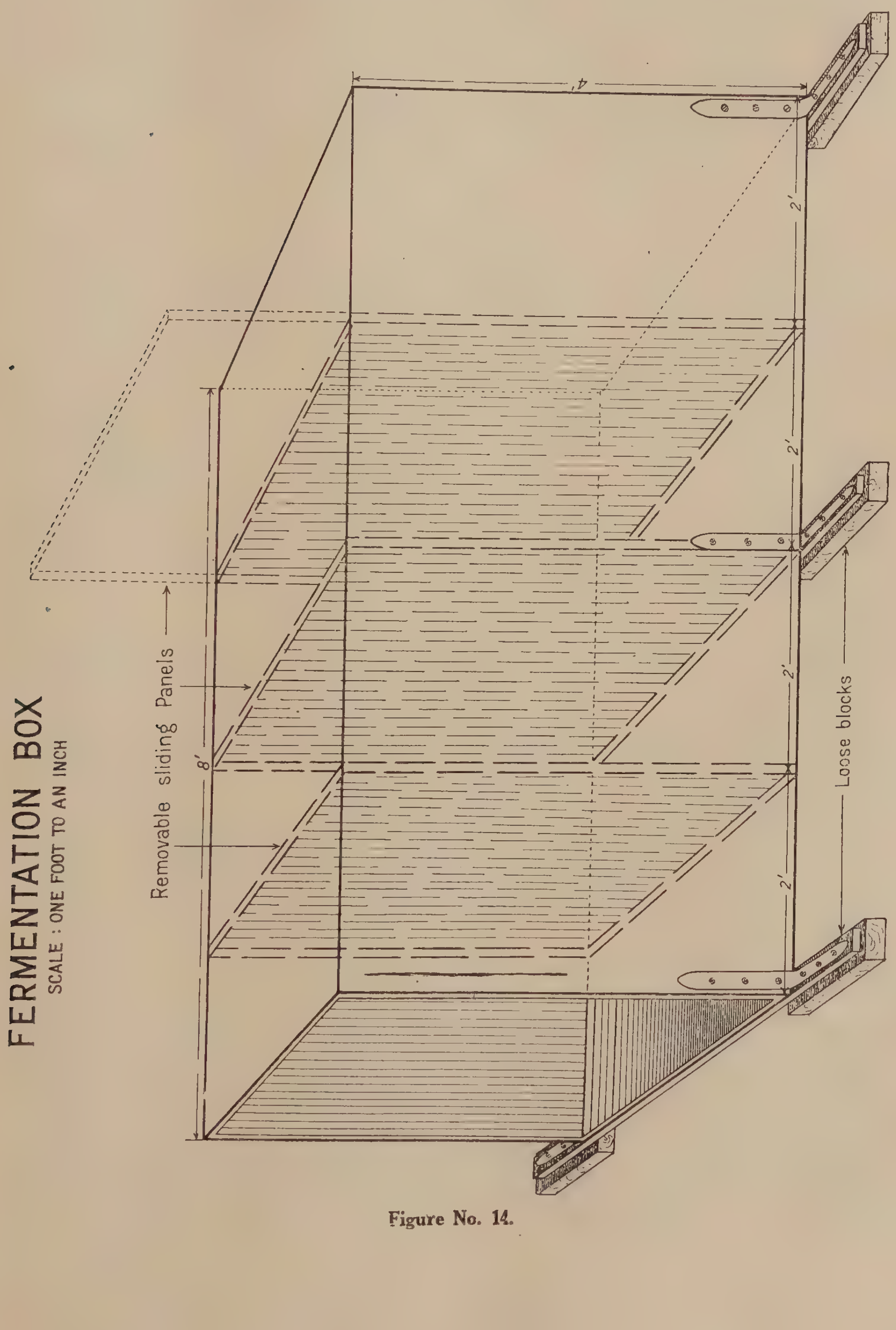


Figure No. 14.

joins are fixed with brass screws, and iron brackets at each end and the centre hold the sides rigid. The bottom consists of fixed hardwood boards with three-eighth inch holes bored 6 inches apart on the equilateral triangle system. A removable grating (similar to that described in system No. 2) could be substituted for the fixed bottom providing it was in four sections, and at the junction of each section, suitable runners were inserted. The box is mounted on concrete or wooden blocks 9 inches to 15 inches above a concrete or earth floor; if the latter, then provision must be made to drain away the "sweatings". The box is housed in a native material or sawn timber building with the back and two sides enclosed.

The Ferment.

The beans should be placed in the "sweat" box to a depth of 2 feet to 3 feet, although quite a good ferment is possible in a 4 feet by 2 feet by 2 feet box at a depth as low as 15 inches. After placing in the box, the beans are covered with banana leaves and fermentation allowed to proceed. Every endeavour should be made to fill the primary box each time. If this is not possible, then the beans in the partially filled box should be spread out as thinly as possible, and covered with banana leaves. When the cacao from the following day's breaking is brought in, it should be placed in another box which is filled with fresh beans, until there is sufficient quantity to completely fill it, when the beans from the previous day are included. The transference of the small quantity from the previous day should be made on the afternoon of the second day or the morning of the third day. The box can now be covered with banana leaves, and fermentation allowed to proceed in the normal manner.

As fermentation continues, transference of the beans from box to box is carried out each alternate day until the process is completed. It is essential that this transference from box to box be carried out in order to get uniform fermentation, and the operation should be accomplished as quickly as possible, otherwise a big reduction in temperature occurs and fermentation is retarded. Further, the beans during the change over should be mixed as thoroughly as possible with a *wooden shovel*. The writer has observed that a common practice adopted in the Territory is to turn every day, and sometimes twice a day. Turning twice per day is unnecessary and detrimental, in that the temperature is reduced each time, whilst every day increases handling, and does not give such good results as alternate days. There are times, however, when it may be essential to turn every day for the first few days in order to raise the temperature, if it is found that alternate days result in a too low temperature.

A fairly high temperature is necessary during the early stages to kill the bean germ, and later to promote and assist in the growth, multiplication, and duties of the various organisms that are responsible for the external and internal changes which the bean undergoes; the rise in temperature accompanying acetic acid fermentation is above the thermal death point of the bean.[2]

The following observations made at the Demonstration Plantation, Keravat, give some indication of the noticeable factors associated with fermentation, and are included as a guide for the planter.

TABLE No. 7.—NOTICEABLE FACTORS ASSOCIATED WITH FERMENTATION.

Hours Period.	Aroma.	Amount Sweatings.	Ferment Flies.	Pulp Colour.	Bean External.	Bean Internal.
0	Sweet ..	..	..	Pink/white..	..	..
8-12	Alcoholic..	Profuse ..	Fairly plentiful	Whitish ..	..	..
24	Acetic ..	Fairly profuse	Plentiful	Creamy/red	Slightly swollen	Dry
36	Acetic fairly strong	Profuse ..	Plentiful ..	Creamy/red	Slightly swollen	Dry
48	Acetic strong	Less profuse	Plentiful ..	Reddish/cream	Swollen ..	Dry
60	Acetic strong	Very little	Decreased	Reddish ..	Swollen ..	Fairly dry slight moisture
72	Acetic strong	Practically none	Very few..	Red/brown..	Swollen full	Fairly moist
84	Acetic strong	None ..	Very few..	Red-brown ..	Swollen full	Fairly moist cotyledons opening
96	Acetic strong	None ..	Very few..	Rich red/brown	Swollen full	As above
108	As above..	None ..	Very few..	As above ..	As above ..	As above
120	Less acetic	None ..	Very few..	As above ..	As above ..	Moist cotyledons open more
144	Faint acetic	None ..	Very few..	As above ..	As above ..	As above
156	Very faint acetic	None ..	Very few..	As above ..	As above ..	Moist cotyledons open

Van Hall[12] states that the "maximum temperature of the fermenting heap remains as a rule under 50 degrees C., and is generally situated between 46 degrees and 48 degrees C.", and Knapp[18] is of the opinion that the maximum temperature should not rise above 50 degrees C. The late Dr. H. R. Briton-Jones,[2] when discussing temperatures during fermentation, says that "normally the temperature does not rise above 50 degrees C., above which the growth of the yeasts and acetic acid bacteria would be greatly inhibited. In fact, after the temperature has risen to 50 degrees C., cessation of growth by acetic acid bacteria is desirable rather than, as some authors suggest, a disadvantage", and as Knapp points out, acetic acid within the cured beans is undesirable from the manufacturing aspect. This writer is of the opinion that the "bite", or acetic flavour, noticeable in New Guinea beans after drying, is probably due in the main to lack of temperature during the later stages of fermentation.

It will be seen, from the above remarks on fermentation temperature, that careful attention must be given to temperature control if a high-grade article is to be produced.

With the strain cultivated in Trinidad, the period of fermentation is up to eight days. Venezuelan Criollo is fermented for one day only,[12] and the Criollo-Forastero hybrid at Djati-Roenggo estate, in Java, for three and a half days. It will be seen, then, that the period of fermentation varies according to the type of cacao grown. Curing experiments conducted by the author on New Guinea cacao, show that the period varies from five and a half days with selected cacao, to six and a half days with bulk plantation cacao. These experiments are by no means complete, and the data available to date shows that climatic conditions and the method of drying influences the period of fermetation. It should, therefore, be clearly understood that until the relationship

between type, climatic conditions, and drying methods has been subjected to further study, no definite period or periods can be given. However, it is considered that as a guide to planters at the present time, a fermentation period of $5\frac{1}{2}$–$6\frac{1}{2}$ days in properly constructed boxes should produce a good marketable product.

The fermentation process may be said to be completed when mitigation of the astringent taste of the bean occurs, aroma is developed, the internal colour changes to yellowish or reddish-brown depending upon the percentage of Criollo or Forastero in the strain, the bean is swollen, the shell becomes leathery and loose from the kernel, the cotyledons have opened, and when the bean is depressed, they close, and, on releasing the pressure, re-open again, and the bean contains a reddish-brown fluid inside which follows the knife when the bean is cut in cross section. On the other hand, insufficiently fermented beans, when compared with those well fermented, are not so rounded and swollen, more astringent, aroma is slight, the shell is soft and close fitting, the inside of the bean is very light coloured or purple according to the relationship of the strain to Criollo or Forastero, they are dry or contain very little liquid inside.

A bad fermentation is further manifested in many instances by the lack of heat developed in the mass, no uniform change in the colour of the bean, mildew of the beans in the boxes, beans stuck together in clumps, a bad odour, and the external colour of the bean very dark bordering on black. The main causes of a bad fermentation, as described, are lack of aeration in the boxes, or the beans become wet with rain before placing to ferment. Should lack of aeration be the cause, then this may be easily remedied by increasing the number of drainage holes in the bottom of the box, elevating the box more above ground level, or inserting bamboo rods into the mass.

It is essential that the boxes after changing be thoroughly cleaned and scraped to remove any mucilage adhering to the sides; sponging with a weak solution of potassium permanganate in wet, humid weather prevents undesirable mould growth in the boxes.

In some countries such as Ceylon, Java, and Samoa, the general practice is to wash the beans after fermentation, to remove the mucilagenous covering on the beans. The question of washing, however, is the centre of a great deal of discussion; it certainly cleans the beans of pulp, making them less liable to become mouldy during drying and after bagging; but, on the other hand, there is a loss in weight, and the shells are more brittle and friable, making them subject to damage in drying, curing, and shipping,[12] more susceptible to insect attack after drying, and from the manufacturers' point of view, the aroma suffers.[16] Knapp[11] puts forward some very sound reasons in favour of washing, and points out that, in some countries like Ceylon and Java, it may be done to assist in the removal of the pulp because of the short period of fermentation, whilst again, on the other hand, it may be "to give the bean a pretty appearance".

Australia, which will presumably be the primary market for New Guinea cacao, imports beans from countries like Ceylon and Samoa which wash, and Trinidad which does not wash. If the market demands a washed cacao, then that requirement must be fulfilled. It is considered, however, that the Australian manufacturers buy on quality or type, and the fact of the cacao being washed or unwashed is a very secondary consideration provided, of course, that the

percentage of mucilage adhering to the beans is not excessive. Nevertheless, until experiments are carried out in New Guinea relative to the costs of production, market price, and storage qualities of washed and unwashed cacao, no definite conclusions can be drawn.

Drying.

When the fermentation process is completed, it is necessary to dry the cacao beans, and there are many methods adopted. Most of the world's cacao is dried by the rays of the sun, and the "methods range from the simplest arrangement, such as, laying out the cacao in a thin layer on a tray or mat, to elaborate drying floors of wood or concrete in a specially constructed building (boucan, barbecue) fittted with movable roofs, which can be readily run on rails to protect the cacao from the sun when it is too hot or from rain ".[2] There are also artificial drying machines which are somewhat extensively used in the Cameroons, Ceylon, Grenada, Bahia, San Thome, and Costa Rica.[18]

Sun Drying.

For estate use there are many types of sun driers which may be used, but for preference one with a large wooden platform covered with a movable galvanized iron or sac-sac roof, or a series of trays which slide one above the other, and covered with a long, narrow, fixed roof. The former type reduces handling to a minimum, allows for constant and efficient turning of the beans, and, if elevated, then the space underneath may be used for grading, storing, &c. It is desirable that the drying floor or trays be some height above ground level as an additional aid in controlling mould growth.

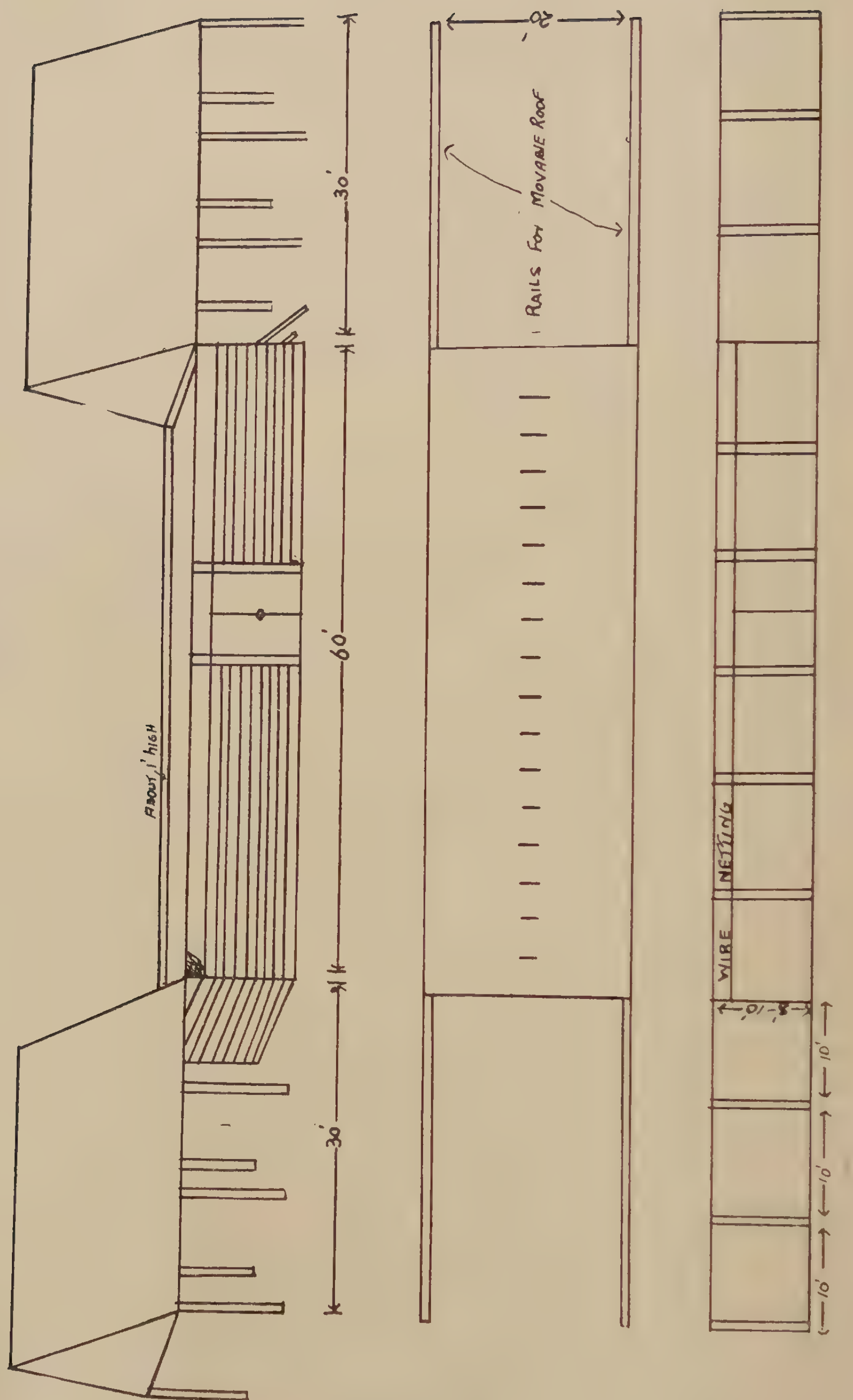
The following diagrammatic sketches illustrate a very suitable type of drying house. A small one, on the same principle measuring 30 feet by 18 feet, was erected at the Demonstration Plantation, Keravat, and gives very good results, another similar dryer measuring 35 feet by 16 feet, with a sac-sac roof has been erected on an estate in the Baining District, and dries 1 ton of cacao. The galvanized iron roof requires one labourer to move it, is mounted on double, ball-bearing wheels running on greased iron rails; the sac-sac roof requires three labourers to move it, and is mounted on large kiln wheels running on hoop or (sarif) iron.

When constructing a drying house of this type, the space necessary to dry 1 cwt. of cacao is about 30 square feet.

During the first half to full day after placing the beans to dry, they should be spread fairly thinly so as to drive off quickly as much surplus moisture as possible. As drying proceeds, the depth of beans should be increased in order to reduce to a minimum the percentage of flat and shrivelled beans occasioned by quick drying.

Throughout the whole period of drying the cacao must be constantly "walked" or agitated with a wooden rake, so as to get uniform drying. "Walking" may be described as follows:—A labourer moves through the beans first in one direction and then in the opposite direction, the beans being thrown into ridges with the feet and a portion of the floor is always exposed, thus the beans are exposed on all sides to the sun, and the floor is kept dry.

It is advisable to heap the beans during the first two nights, so as to aid the additional slow fermentation which takes place during drying and assists greatly



30'
60'
30'
20'
RAILS FOR MOVABLE ROOF
ABOUT 1' HIGH
WIRE NETTING
10'
10'
10'

Figure No. 15.

in obtaining a uniform product. Do not heap the beans at night in wet weather, and when exposed during the day, if the sky is overcast, then the beans must not be spread so thickly as in sunny weather.

In some cacao-producing countries such as Trinidad, it is customary to "dance" the cacao, and the operation is carried out in the early morning three to five days after drying commences. The object of "dancing" is to spread the mucilage adhering to the beans evenly over the surface, give greater strength to the shells, give the beans a polish, and to remove mildew. The correct time to "dance" depends on the experience of the planter, and can only be ascertained by tests. Should the beans be too soft, they may become unduly flattened, and, if drying has proceeded too far, then breaking and cracking are liable to occur.

The method adopted is to make conical heaps each containing about 4 cwt. of beans, they are lightly sprinkled with water from time to time, and lightly walked over with a sliding foot movement of the operators. It is important that the beans be continually shovelled back into the centre of the heap, so as to retain the conical shape, otherwise the beans are unduly flattened and subjected

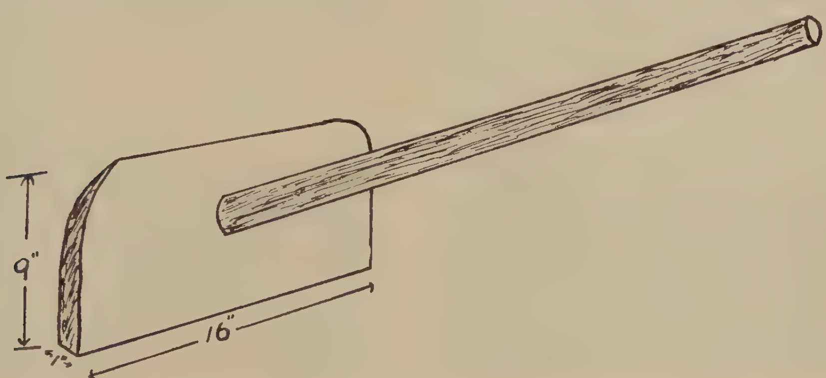


Figure No. 16.—Cacao Rake.

to an unequal amount of "dancing". The amount of water required will depend on the appearance of the beans and the knowledge of the planter; usually it is about 1 gallon per 112 lb. beans. Should mould growth be severe, then it is advisable to add a little lemon juice to the water, or use a very weak solution of permanganate of potash. As dancing proceeds, the beans must be carefully watched, and, as soon as they exhibit a polish, the operation should cease, otherwise a dull colour will result. "Dancing" generally takes about 30 to 45 minutes and it is estimated that ten labourers will dance about 4 cwt. in this period.

When the process is completed, the beans are re-spread in a comparatively thin layer over the surface of the drying floor, and the drying is allowed to proceed fairly rapidly. As the beans are wet, they must be frequently turned, but it is not advisable to "walk" them during the first half-day, therefore, a type of wooden rake is used (Fig. No. 16) until "walking" can be practiced, and maintained until completion of drying. Although the second period of drying is allowed to proceed fairly rapidly during the first stage, it must not be too fast, otherwise the finished product consists of too many wrinkled or flat beans with a split outer shell. In order to obviate this defect, it is often necessary to spread the beans more thickly after the first one and a half to two days, and allow drying to take place less quickly.

The period of drying depends on the weather; under normal conditions six to seven days are sufficient, and this stage is judged from a practical point of view when the beans crackle, will break with a snap in the early morning, and the moisture content is within the limits of 5-7 per cent. After drying, the beans are allowed to cool and may be graded before bagging.

It is essential that the utmost cleanliness be practiced during drying, in order to prevent undesirable mould growth, and the drying floor or trays should be scraped free of mucilage, especially for the first two to three days of drying and after "dancing".

Artificial Drying.

Sun drying is to be preferred, but where conditions are unsuitable, hot air can be utilized. There are several manufacturers of artificial drying machines, the best known, perhaps, being the Gordon Caca Dryer as illustrated by Van Hall.

Plate No. 14.

Plate No. 15.

Plate No. 14.—Illustrates a combination drying-house, bulk and seed store at the Government Demonstration Plantation, Keravat. Dimensions are 30 feet long, 18 feet wide, 10 feet high.

Plate No. 15.—Illustrates the movable roof on the building, shown in Plate No. 14.

It is generally agreed that the changes which occur during fermentation are continued during drying. However, if the temperature is too high (and it can quite easily occur during artificial heating) no continuation of fermentation takes place, and the percentage of inferior beans is increased. Should artificial drying be necessary, then an even temperature must be maintained, and the beans constantly turned as in sun drying. A rotary type drier allows for turning of the beans which is more efficient than in sun drying.

The drying of cacao together with copra, or, in driers constantly used for copra, or by means of open smoke driers, is not recommended for many reasons, such as—

(*a*) There is absorption of copra odour by the cacao.

(*b*) The period of drying for copra is, in the majority of instances, much faster than cacao.

(*c*) At no stage during drying should the beans come into contact with metal such as is used for copra trays.

(*d*) The type of copra driers used in the Territory does not permit the constant turning that cacao requires.

(*e*) Smoke and other odours are absorbed by the cacao in open smoke driers.

Marketing.

Market competition is so high that, when a commodity is offered for sale from a newly producing source, it is essential that the commodity should be of the highest quality if it is to successfully compete with the known standards of older producing countries.

The concensus of opinion amongst Australian chocolate and cocoa manufacturers is that New Guinea cacao beans are not comparable with those of Ceylon, Brazil, Ecuador, Panama or Trinidad, and that, generally speaking, they are not equal in quality to West African beans (Accra).

The origin of New Guinea cacao, as already outlined in a previous section of this paper, shows it to be definitely linked with the cacaos of Ceylon, Trinidad, Java and Samoa, hence the type must be comparable to that grown in these countries, and superior to that of West African or Accra cacao.

Reports received from various manufacturers in Australia, regarding different consignments of New Guinea cacao beans, show that up to 9 per cent. are weevily, 13 per cent. hard and flinty, 7½ per cent. mouldy (internal); in an appreciable percentage the husk is shrunken and the beans flat, and in most beans there is an acid component which imparts a "bite". Further, it is recorded that unfermented beans have been submitted, beans with a "smoky" aroma, beans with a "copra" taint, and beans with a "tar-like" aroma.

The following table shows a comparison in individual bean weights of five separate consignments of New Guinea cacao, with average bean weights of Ceylon, Trinidad and West African (Accra) cacao.

TABLE No. 8.

Origin of Beans.	Weight of beans in grammes.
New Guinea Consignment No. 1	1.34
New Guinea Consignment No. 2	1.27
New Guinea Consignment No. 3	1.28
New Guinea Consignment No. 4	1.17
New Guinea Consignment No. 5	1.20
Trinidad	1.295
Ceylon (Caracas cacao) [15]	1.27
Ceylon (Forastero-Cundeamor) [15]	1.133
Ceylon (Amelonado) [15]	1.05
West Africa (Accra) [17]	1.020

From the above table, it will be seen that the New Guinea beans compare very favorably with the best Ceylon and Trinidad beans, and are superior to the Ceylon Forastero-Cundeamor, and Amelonado types of cacao, also the West African type.

Another point raised by the manufacturers is that New Guinea beans arrive in small, irregular consignments, and as they import their stocks in large consignments from the country of origin, there is no necessity for them to purchase small lots of New Guinea cacao from time to time. The following example might be cited in this connexion:—In January and February, 1937, the imports of cacao beans into New South Wales from West Africa and New Guinea were, January 500 tons, February 580 tons from West Africa, and January 2 tons 9 cwt., February 13 tons from New Guinea. The West African beans were in six consignments and five consignments respectively, and the New Guinea beans in three consignments and four consignments respectively. It is interesting to note that in 1936-1937 the imports of New Guinea beans into New South Wales alone constituted only 3.66 per cent., compared with 81 per cent. from West Africa, and 15.4 per cent. from other countries.

It would appear that the main factors affecting the New Guinea bean are, the very high percentage of weevily, hard, flinty, and mouldy beans, plus the shrunken appearance and acid component they contain; also the cacao, in general, is affected by the small, irregular shipments. The writer considers that the control of these factors rests with the producer, and that the acid component is a feature of fermentation and curing, rather than of type or ecological conditions.

The grading of cacao would ensure standardization of size, shape, and freedom from foreign matter, whilst inspection ensures that the product has been prepared for sale, in such a manner that the quality is commensurate with the standard required. The shipping of small and irregular consignments creates one of the biggest difficulties when establishing a new industry, and the inauguration of a central marketing board, even at this stage of production, is worthy of consideration. Such a board could be constituted with or without Government representation, and modelled on similar lines to the Cocoa Producers Association of Trinidad. Its function, in addition to shipping, could also be the control of grading and inspection.

TABLE No. 9.

Territory of New Guinea.

	lbs.
1932-33	109,340
1933-34	197,637
1934-35	235,180
1935-36	267,406

Diseases of Cacao.

In this section an endeavour has been made to describe, as simply as possible the cacao diseases that are present, or likely to occur, in New Guinea. Facilities for disease investigation in the Territory are, as yet, somewhat limited, and a great deal of the information has been obtained from publications by the late H. R. Briton-Jones,[2] Arnold Sharples,[23] and Melville T. Cook,[4] to whom the writer gratefully acknowledges the source of this information. Other information is from observations made by the writer at the Demonstration Plantation, Keravat, and on several estates in the Territory where cacao is under cultivation; also during his period of study under the late H. R. Briton-Jones at the Imperial College of Tropical Agriculture, Trinidad, British West Indies.

Root Diseases.

Rigidoporus Microporus (Swartz) van Overeem.

This root fungus is dealt with rather fully by Sharples,[23] as *Fomes lignosus*, and Briton-Jones[2] as *Rigidoporus microporus*. According to Petch, who is quoted by Briton-Jones,[2] two different species of fungus have been confused under the name of *Fomes lignosus*; recently De Jong has identified the fungus known as *Fomes lignosus* in the Eastern Tropics as *Rigidoporus microporus* (Swartz) van Overeem.[2]

Rigidoporus microporus has a great variety of host plants such as rubber, coffee, cacao, coconuts, mango, breadfruit, cassava, &c., and many species of forest plants. In New Guinea this fungus has been observed on cacao and coffee.

Trees are usually attacked singly or in small groups throughout the estate, above ground the leaves wither, turn yellow or brown, and drop off, followed by a general die-back of the twigs. This defoliation and die-back may occur suddenly, being complete within a few days, or occur gradually over a period of several weeks. If the primary infection takes place on the tap root, then the tree may be blown over before the symptoms are noticeable above ground.

On the roots, the mycelium of the fungus is very apparent, the young mycelium strands as the fungus advances are white, branched, and may exhibit a fan-like appearance; the older strands are stout and cord-like up to $\frac{1}{4}$ inch in diameter, and adhere closely to the surface of the root. These cords may be white to brownish-yellow, sometimes tinged with red, they follow the roots in a longitudinal manner and constantly unite to form a network.

If the dead tree is not removed, the fungus fructifies in the form of brackets which may be single, or in groups, or fused together. These brackets vary in size from a few inches up to 1 foot in width, and about $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter, the marginal end being thinner than the basal end attached to the tree stump or trunk. Fresh brackets exhibit a zonation on the upper surface which has concentric grooves running parallel to the outer edge, and, in the young fructifications, the outside margins are bright yellow. The underside of the bracket is bright orange in colour, pitted with minute holes in which the spores are produced; as the bracket ages, the colour becomes paler. On cross section, the bracket shows two distinct layers, the lower layer is reddish-brown and pitted, whilst the top layer is white and fibrous.

Rigidoporus microporus not only produces the bracket fructifications for spore production, but the fungal strands which caused the initial infection of the roots are able to use the host for penetrating a few feet through the soil until contact is made with a further source of food, such as a piece of dead wood, or living roots.

The writer has observed that, in New Guinea, *Rigidoporus microporus* does not appear to attack the cacao until it is about eighteen months old, and trees from this age upwards to at least seven years of age, are liable to infection. The worst period, however, seems to be from two years to five years.

Brown Root Disease (Fomes Noxius Corner).

This disease has been recorded on cacao from Ceylon, Gold Coast, Samoa, New Guinea,[2] and this writer has also observed its presence in New Guinea. Although Brown Root Disease is not considered a very serious disease of cacao at the present time, nevertheless, it has been known to cause considerable loss in Hevea Rubber.

The symptoms of the disease are most characteristic, and field identification is fairly simple. The diseased roots are encrusted with soil to a thickness of 3-4 mm., and a similar encrustation may be found at the base of the stem for a few inches. This layer of soil, which can also contain small stones, is so firmly held to the root by the tawny brown threads of the fungus, that it cannot be washed off with water. In the later stages, the brown hyphae or threads has a black, brittle covering which gives the root a black appearance.

The diseased wood is also characteristic; when soft, it contains a network of thin brown lines consisting of hyphae; when hard, the brown colour is in broad bands. The roots decay, and, when an advanced condition has been reached, the brown lines exhibit a honeycomb structure. This is particularly noticeable if the wood is soft.

Fomes noxious, unlike *Rigidoporus microporus,* cannot travel through the soil, hence its spread is entirely by root contact, and its appearance in the estate occurs only in single cases.

The fungus rarely fructifies, as it seems that special climatic conditions are required. The fruiting body is a hard bracket which, when growing, is purplish-brown to almost black with a yellow margin; when mature and dry, it is purplish-brown to blackish-brown, with concentric narrow black or yellowish-brown zones towards the margin, smooth, and sometimes concentrically furrowed. The underside is dark brown to almost black in colour, and often covered with a greyish bloom. The brackets are 3 to 4 inches wide and approximately ½ inch thick, and may be produced in large groups running several feet in length, and joined together on the lower surface. On cross section, the tissues consist of a thin, dark, hard top crust, brownish or yellowish brown internal tissue usually zoned with curved lines, approximately parallel to the margin, and a lower dark layer of vertical tubes in which the spores are produced on the hymenium, or skin.

Red Root Disease (Sphaerostilbe Repens).

This fungus attacks Hevea rubber, paw-paw, canna, *Erythrina* spp., hibiscus and citrus, in addition to cacao, and was first recorded from Ceylon.[2]

In attack by *Sphaerostilbe repens* there is no mycelium seen on the surface of the bark of diseased roots. The cortical tissues of the roots are decayed and the bark can be peeled off; this diseased bark has a most objectionable sour smell, which is also noticed in the surrounding soil. On the inside of the bark and the surface of the wood are black, reddish, or yellowish branching strands of mycelium which measure up to ¼ inch in diameter, and are white on cross section: these rhizomorphs or mycelium produce the hyphae or threads which enter the tissues of bark and wood, setting up decay.

Wet Rot (Ganoderma Pseudoferreum (Wakef) van Overeem et Steinmann).

This fungus has been reported from the Dutch East Indies as causing severe damage to cacao in addition to coffee, rubber, tea *Albizzia* spp., *Tephrosia* spp., *Crotalaria* spp., &c.

According to Briton-Jones,[2] there is no record of the fungus attacking cacao outside the Dutch East Indies, but it is present in Malaya, where it causes Wet Rot of hevea rubber.

The symptoms of the disease are, that in the larger roots the woody tissue becomes a soft spongy mass out of which water may be squeezed with the fingers. The attacked roots have characteristic red rhizomorphs on the outer surface, and these rhizomorphs are formed by red mycelial strands, which fuse and form a continuous membrane. The membrane and individual strands are not easily seen when the roots are first taken from the ground, as the soil remains attached, being held by the mycelium, hence, it must be washed away before the membranes and strands can be recognized. When the roots have decayed, the membranes are a blackish-violet colour and single separated rhizomorphs are rare. When young, the strands and membranes are light red, but as they dry the colour fades to a dirty white, but reappears on moistening; when mature, the colour is dark red and remains unchanged when dry.

In surface roots, the disease is more pronounced on the under side, the lower portion may be rotted whilst the upper portion remains untouched.

The fructifications sometimes develop at the base of the diseased trees, and, in the early stages, appear as a round or spherical knob-like proliferation up to 2 inches in diameter, on which yellow or brown spots appear when it is touched. As development proceeds, the basal portion turns grey, then brown, and eventually brownish-black, whilst the crust becomes practically smooth. The knob grows into a hood, and if very little growth takes place at the base, then a stalk is formed; usually, however, no definite stalk is formed. The upper surface of the bracket is smooth, or maybe grooved with irregular excrescences on the surface, is dark coloured, with cinnamon, brown, or khaki coloured narrow wavy zones with a bright chestnut-brown zone which is subresinaceous, up to 10 mm. wide and situated near the margin; eventually, the upper surface becomes a dull brown from deposited spores. The margin is white, thin, and often lobed.

Armillaria Root Rot or Collar Crack (*Armillaria Mellea*).

This disease has been recorded on cacao in Togoland, where severe loss has been caused. Its distribution is general on the Gold Coast, it is recorded from Uganda and St. Thomas Island, and is known to attack tea in Ceylon and Java.

Infection occurs per medium of the lateral roots, the fungus spreading upwards towards the crown, where it attacks the stem and tap root. The white mycelium travels from the bark into the wood tissue, where, eventually, the medullary rays section is occupied by the mycelium which develops into white sheets of xylostroma or fungus tissue that increase in thickness exerting a lateral pressure on the tissues causing cracks. Internally, the cracks are numerous, but only the large ones are noticeable externally, and these have the xylostroma protruding in the form of white, cream, or dark brown frills. The cracks may extend to some distance up the stem, but by the time they have reached a few feet, the tree is usually dead.

Cracks are to be seen in the tap root, and later, due to secondary infection by other fungus and organisms, it becomes a vile smelling, bright yellow pulp. This destruction of the tap root causes the tree to fall over, hence, it is seldom that defoliation occurs before the tree falls.

Control of Root Diseases.

The measures of control for the foregoing root diseases are essentially the same. Stumps of forest trees that are allowed to remain and rot after clearing provide the host for the fungus, as it is able to derive nourishment from the roots of the stump as it moves along them to infect the roots of growing plants, which are attacked as soon as they come into contact with the infected stump roots. The fungus, after attacking the new host, follows its root system, and so infects any more healthy roots that are contacted, thus disease is spread throughout the estate. Certain fungus, such as *Rigidoporus microporus,* have the ability to move through the soil for some distance from the host, and so attack healthy plants without contact with infected roots being necessary.

Fungi also produce spores, which can cause infection, and, as one authority (2) points out, it is possible for root disease outbreaks on land that has been stump free for years. Most of the root disease fungi depend on soil factors and moisture, some favour clayey soils, others fairly wet soils or soils rich in humus, whilst others show preference for acid soils.

It is recommended that diseased trees be removed and burnt in situ, also that trenches be dug around the trees to a depth of at least 18 inches. The soil, and sections of roots removed in digging should be thrown inwards towards the diseased tree, as the soil and roots may be infected, and, if thrown outwards, the disease is spread if conditions be conducive to its development.

The writer suggests the following procedure in dealing with diseased trees:—Tentatively mark off an area 8 feet to 10 feet square around the infected tree, then remove the tree making a hole approximately 5 feet square and at last 3 feet deep, throw the soil outwards from the hole but inside the 8 to 10 feet square. Place the cut up portions of the tree (roots, stem, branches, &c.) in the hole and burn, then throw back the soil, dig the isolation trenches, throwing the soil removed also into the hole. As this operation is being carried out, treat the soil in the hole as it fills with a 2 per cent. solution of copper sulphate (bluestone).

Do not replant for at least twelve months, and before replanting, re-open the hole, apply a liberal amount of lime, and allow the hole to remain open for some time before planting the new seedling. Any forest stumps in the vicinity must also be removed.

Stem Diseases.

Die Back (Diplodia Theobromae Nowell).

Die Back is a debility disease which affects cacao wherever it is grown. In New Guinea the writer has observed the presence of Die Back on every estate visited, and considers it the most important "above ground" disease of cacao in this country at the present time.

According to one authority, (2) a fungus belong to the genus *Phomopsis* is often associated with *Diplodia theobromae,* and that the first invasion in many cases may be *Phomopsis* spp. which is later followed by *Diplodia theobromae.*

The symptoms of the disease are that the tree may produce small dark green or yellowish coloured leaves, which later die and drop off, leaving the ends of the branches and twigs exposed. These small leaves coincide with each growth flush and gradually appear lower down on the branches as the disease progresses, and

the twigs die back further from their tip. In many instances the attack can be quite sudden, and in which case the leaves quickly die and drop off, leaving the ends of the branches and twigs exposed, and these rapidly die back in their turn.

Die Back depends largely on the nature of the factor or factors responsible for a set back in the growth of the cacao. Some of these factors may be chronic, whilst others of a temporary nature can be most drastic while they last. External factors such as prolonged dry weather, waterlogging of the soil, poor drainage, wind exposure, soil deficiency, injudicious pruning, bark injury by knives, hoes, &c., lack of shade, very shallow planting, and diseases such as root rots, branch and stem cankers, thread blights, &c.

In the case of prior infection by root fungi, it is possible that only one side of the tree may exhibit the symptoms of Die Back if only one side of the root system is affected, also it may be rapid or gradual, depending on the speed of invasion by the fungus.

The control of Die Back is of a general nature by improving the conditions in which the plant is growing; hence, attention must be given to factors such as shade, drainage, diseases and pests, exposure, maintenance of soil fertility, &c. Dead and diseased branches should be removed to make way for new growth, which is allowed to develop in the correct position on the branches, and in the direction most suited for fruit production and disease avoidance. The pruning of living branches and the removal of dead and diseased tissue alone does not control the disease, it merely brings about a temporary alleviation of the condition, hence, the Die Black problem can only be solved by remedying the predisposing causes.

Pink Disease. (Corticium Salmonicolor B. and Br.)

Pink disease is very prevalent in the Mandated Territory, and attacks a large number of hosts such as cacao, coffee, lime, *Crotalaria* spp., *Tephrosia candida,* orange, mandarin, grapefruit, pomelo, tripetalum, &c. Although prevalent, the disease causes very little damage to cacao in New Guinea, but *Crotalaria anagyroides* and *Tephrosia candida,* the two species of temporary shade that are used in cacao cultivation, are severely attacked when twelve months to eighteen months old.

Corticium salmonicolor is readily diagnosed on account of the salmon-pink encrustation which surrounds the branch or twig up to a distance of a few feet. The bark splits and rots away, and the infected branches become defoliated and die. As the age of the fungus increases the salmon-pink colour changes to greyish-white.

Abnormally wet conditions are necessary before the fungus develops to any extent on cacao, although the writer has observed that young seedlings appear susceptible if the disease is allowed to spread on the temporary shade, especially *Crotalaria anagyroides* which is attacked to a greater degree than *Tephrosia candida.*

For the control of pink disease all affected branches should be removed and destroyed, and at the same time, the remainder of the tree should be "opened up" if necessary by judicious pruning. Attention must also be paid to the conditions of moisture and humidity which depend on drainage, overhead shade, canopy of the cacao tree, and exposure of the locality in addition to the rainfall. The evidence of the disease on the temporary shade must also be considered, and suitable control measures adopted.

Thread Blights. (Corticium spp. and Marasmius spp.)

Thread blights affect a large number of plants in the virgin bush in addition to cultivated crops, such as cacao, coffee, rubber, tea, &c. In general, they belong to the species Corticium and Marasmius, and although the threads vary in colour depending on age and species, the symptoms are so characteristic that field identification is very simple.

The threads, which run longitudinally up and down the branches and twigs, invade the leaf by travelling along the leaf stalk on to the surface of the leaf itself. By the time the threads have reached the leaf they have branched considerably, and the surface of the leaf may be covered with very fine threads. In wet weather the threads are easily removed from the twigs and leaves, but in dry weather they are brittle. The fungus penetrates the cortical tissues which are killed, the diseased leaves die and either drop off, or remain suspended in the air by means of the threads; and in wet weather a dark brown fluid may drip from the leaves as they decay. The fungal threads are usually found on the under surface of the leaf, and this factor, plus the mid-air suspension of the leaf, makes diagnosis very simple.

The disease is spread by means of dead leaves, &c., on which the fungus is growing, being blown through the plantation and lodging on healthy trees. Wet, humid conditions are most favorable for thread blights, hence the worst infection is likely to occur during the wettest periods of the year.

Control of the disease consists of removing and destroying affected leaves and twigs, and attention to the pruning of the permanent shade at the beginning of the wet season, so that a dense shade canopy does not result.

Thread blights are to be seen throughout the whole of New Guinea, but the writer has noticed that the damage occasioned to cacao is very slight, the attacks occurring sporadically in the estates.

Red Rust or Algal Disease (Cephaleuros Mycoidea Karst., C. Virescens Kunz., Mycoidea Parasitica Cunn.).

This disease is very wide spread throughout the world, and is present in New Guinea. It appears mostly on the upper surface of the leaves, in patches more or less circular in shape, and up to one centimetre in diameter. The patches vary in colour from orange-yellow to a rusty-red, and may be found singly, in groups, or scattered over the surface of the leaf. When young, the patches are slightly raised, and later the centre may be depressed due to the death of the underlying cells.

The injury to the leaves is not great, but if conditions are suitable, then the twigs may be attacked, causing them to slough away. The effect of the disease is cumulative, and the severity of attack increases as the trees are weakened.

The best method of control is by improving the conditions under which the cacao is growing, so that the vigour of the trees is sufficient to ward off any attack. Loss of vigour may be due to one or more factors, such as bad drainage, insufficient windbreaks, lack of pruning, soil exhaustion, &c., and when these conditions have been improved, then pruning to reform the heads of the trees should be carried out.

Pod Diseases.

Pod Rot, Canker, Chupon Wilt (Phytophthora Palmivora Butler; or Phytophthora Faberi Maubl.).

Phytophthora palmivora is one of the most destructive diseases affecting cacao, and is present wherever cacao is grown. In New Guinea, it has been observed by the writer, but no infection assessment has yet been made. Bryce[1] has recorded and described the disease, in its application to the Territory.

Pods of all ages are liable to attack, from the very smallest cherelles to fully ripe pods. Infection may take place through wounds, and if the moisture conditions are suitable, then healthy, uninjured pods are readily attacked. Any section of the pod surface can be primarily infected, although in half or fully grown pods the attack generally occurs at the stem end or tip of the pod. The point of attack on the pod is clear brown in colour, and the boundary between the infected and healthy tissue is quite distinct. This discoloured area rapidly extends so that in wet weather, the whole pod may turn brown in a few days, and be covered with a white mass of fungal growth. Examination of this growth has shown that frequently very little mycelium, conidiophores, or conidia of *P. palmivora* are present, and that the white covering consists mainly of *Fusarium* spp.[2]

As the disease progresses the pods turn black, and may be covered with a whitish fungal growth. Should the pods be attacked when the beans are still against the inside of the shell (immature pods), then the fungus, after moving through the pod husk, attacks the beans and completely destroys them. When the pods are fully grown, the beans are free and may not be affected at all, even if the husk is destroyed.

Generally, the diseased pods do not fall from the tree, and the mycelium of the fungus is able to pass through the pod stem into the branch or trunk tissues and cause canker. There is not much indication of canker in its early stages, and frequently the first noticeable factor is the discharge of a darkish coloured fluid which runs down the surface of the bark and dries a rusty-red colour. The fungus spreads under the outer bark layers, through the inner cortical tissues and the cambium, and when the diseased parts are exposed they are brown or claret-red in colour, have an unpleasant odour, and are separated from the healthy tissue by a dark brown line. One or more cankers may surround the branch or main stem, causing the section above the infection to die. As a general rule, cankered trees have an unhealthy appearance, and certain of the main branches are either dead or dying.

When a chupon or sucker is attacked it usually dies back from the tip. Infection generally occurs in the axil of a leaf, but it can also take place on the leaf blade, or petiole, and move backwards into the stem. The affected section has a water-soaked appearance in the first instance, and later, becomes sunken and the colour darkens. The disease travels upwards, downwards, and around the stem, which is finally girdled, and the portion dies above the lesion.

In controlling *Phytophthora palmivora,* it should be remembered that the chief source of infection is from the diseased pods that remain on the tree; hence, treatment of this material is of primary importance. According to the late H. R. Briton-Jones,[2] canker is not a "direct source of infection to pods on other branches because it rarely, if ever, produces spores of *P. palmivora*". The control

recommended against canker, is to cut out the diseased tissue, and paint the surface with a fungicide. In excising the canker spots, it is important to use a sharp knife and trim properly, as the fungicide provides only a temporary protection until the tree forms an effective barrier by the production of callus.

The removal and destruction of diseased pods is not effective, because the conidia of the fungus are produced before the pod turns black on the tree; hence, spraying with bordeaux or burgundy mixture to protect the healthy pods is recommended by many authorities. The removal of diseased pods at frequent and regular intervals is essential, however, in the prevention of canker. Removal and destruction of the pods provides little difficulty, but spraying has many undesirable factors. Spray efficiency depends largely on the weather conditions, which, in the tropics are most variable, and the point at which spraying is economic in relationship to disease control, cost of application, and yield, is a matter of contention. From a practical aspect, the most satisfactory method of dealing with *Phytophthora palmivora,* is to reduce atmospheric humidity by efficient drainage and shade balance, excision and treatment of cankered spots, and regular and frequent collection and destruction by burning of diseased pods.

Diplodia Pod Rot (Diplodia Theobromae Nowell).

The writer has noticed the presence of this disease on a number of estates in the Mandated Territory, and, although it is widespread wherever cacao is grown in the world, it is not considered serious.

Diplodia, theobromae differs from *Phytophthora palmivora,* in that it is unable to infect healthy pods, hence, is dependent mainly on wounds for its entry. It is possible, however, for infection to occur on over-ripe pods, or pods previously attacked by *P. palmivora.*

The disease is manifested by the formation of small pustules under the epidermis in the early stages of attack. These pustules are numerous all over the affected tissue, which becomes slightly raised, giving the pod a roughened appearance. The pustules contain numerous spores, which, in wet weather, are released in the form of white, grey, or black tendrils, the colour depending on the stage of maturity. The fungal mycelium rots the pod and penetrates inside to destroy the beans.

The control of diplodia pod rot depends on the reduction of pod damage by insect pests, wounding of immature pods during harvest, and picking of all pods when they are fully ripe.

Referring to cacao diseases in general, it will be seen that ecological conditions are the biggest factors in the development, spread, and control of fungus. The utilization of fungicides in the prevention and control of fungus diseases in the humid tropics plays a very small part in comparison to general growth factors, and it is doubtful, with cacao prices fluctuating so much in recent years, whether spraying is economic on large-scale crop production.

Diseases such as Phytophthora Pod Rot, Thread Blights, Pink Disease, &c., are at their worst during the wet periods of the year; hence, any measure of control by spraying would mean frequent and regular applications.

Disease control must, in the first instance, be approached from the ecological aspect, any improvement in the conditions under which the cacao is growing, enables the tree to not only maintain, but increase, its vigour and subsequent disease resistance. A study of the local conditions, and the trees themselves, with a view towards effective drainage, shade balance, humidity control, and maintenance of soil fertility, allied to estate sanitation provide to a large extent, the most essential factors in disease prevention and control.

The selection of planting material from strong, healthy trees, and the rigorous culling of unsuitable nursery seedlings, is also important and cannot be too strongly stressed. The planting out of undesirable seedlings from undesirable sources, creates, from the outset, a major difficulty in the prevention and control of disease.

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APPENDIX A.

YEARLY RAINFALL IN INCHES FOR 1937, AND ANNUAL AVERAGE RAINFALL AT ALL STATIONS IN THE TERRITORY.

District.	Number.	Locality.	Rainfall, 1937.	Years recorded.	Average.
New Britain ..	1	Arawe Plantation	204.82	4	175.89
	2	Gasmata ..	267.73	20	244.53
	3	Keravat ..	103.29	8	104.74
	4	Kokopo ..	65.41	11	83.10
	5	Kolai ..	225.04	5	209.50
	6	Lindenhafen ..	308.60	18	225.75
	7	Notre-Mal ..	158.07	9	164.46
	8	Palmalmal ..	200.62	6	205.37
	9	Pondo ..	199.93	11	176.58
	10	Rabaul ..	98.90	24	88.75
	11	Rapopo ..	74.46	5	80.12
	12	Ring Ring ..	337.72	3	297.76
	13	Sum Sum ..	200.95	5	146.32
	14	Talasea ..	200.40	20	172.24
	15	Tobera ..	83.50	7	81.07
New Ireland ..	1	Kalili ..	227.18	14	192.44
	2	Kavieng ..	116.04	21	120.34
	3	Namatanai ..	143.43	20	136.90
Kieta	1	Hakau ..	89.61	2	111.18
	2	Kieta	95.72	21	119.19
	3	Rugen ..	113.34	5	102.47
Manus	1	Lorengau ..	143.19	20	150.60
Sepik	1	Aitape ..	110.12	17	99.23
	2	Wewak ..	97.10	9	88.11
	3	Angoram ..	106.34	3	95.08
Madang	1	Madang ..	119.16	20	140.11
	2	Kulili	136.71	3	143.60
	3	Urit-Kurum ..	134.41	13	115.07
Morobe	1	Baiune ..	74.09	4	67.65
	2	Bulwa ..	63.88	3	60.20
	3	Bulolo ..	61.78	7	56.06
	4	Edie Creek ..	114.65	8	106.58
	5	Kaiapit ..	93.87	10	85.15
	6	Ramu	75.47	4	77.56
	7	Sattleberg ..	188.76	13	176.55

APPENDIX B.

MONTHLY RAINFALL AND WET-DAY AVERAGES AT ALL METEOROLOGICAL STATIONS IN THE TERRITORY.

Monthly Rainfall and Wet-Day Averages.

—		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly Average.
New Britain.														
Monthly Rainfall Average for nineteen years—Monthly Wet-Day Average for thirteen years.														
Gasmata	*R.	5.28	5.79	6.50	10.83	25.26	33.94	37.13	44.50	33.70	19.54	13.36	7.48	243.31
	*W.D.	10.6	11.2	12.0	13.8	20.4	23.5	23.4	15.2	23.5	17.3	14.4	10.4	205.7
Monthly Rainfall Average for seven years—Monthly Wet-Day Average for seven years.														
Keravat	*R.	12.19	7.20	10.57	11.96	8.06	5.93	7.52	5.61	7.01	9.56	11.57	9.06	106.27
	*W.D.	22.0	16.6	21.6	21.7	20.3	15.1	19.0	18.0	16.1	18.6	19.9	21.7	230.6
Monthly Rainfall Average for ten years—Monthly Wet-Day Average for ten years.														
Kokopo	*R.	10.46	6.65	10.68	7.20	5.86	3.78	6.63	7.05	3.70	5.21	6.54	11.09	84.85
	*W.D.	15.5	15.0	17.7	15.9	11.6	9.8	13.0	12.1	9.0	9.9	11.7	13.2	154.4
Monthly Rainfall Average for four years—Monthly Wet-Day Average for four years.														
Kolai Plantation	* R.	7.24	7.31	7.90	9.71	18.42	23.63	33.54	42.18	19.50	18.10	13.09	7.44	208.06
	*W.D.	12.3	10.0	10.0	11.7	17.7	17.5	20.2	20.5	18.0	15.3	15.3	11.0	179.5
Monthly Rainfall Average for seventeen years—Monthly Wet-Day Average for six years.														
Lindenhafen	*R.	7.14	6.31	5.73	11.75	27.69	35.18	39.65	44.98	31.57	20.34	14.07	8.22	252.63
	*W.D.	10.4	12.8	12.8	16.4	19.4	21.4	20.2	24.2	24.6	14.8	15.0	12.0	204.0
Monthly Rainfall Average for eight years—Monthly Wet-Day Average for eight years.														
Notre-Mal	*R.	31.88	16.42	19.81	13.83	8.71	8.26	7.23	7.93	6.34	7.05	9.88	15.33	152.67
	*W.D.	24.7	19.4	21.2	18.6	17.7	16.7	16.5	16.6	15.0	16.1	17.6	19.0	239.1
Monthly Rainfall Average for ten years—Monthly Wet-Day Average for ten years.														
Pondo	*R.	35.75	24.33	19.02	16.97	9.02	7.85	10.41	9.91	7.95	6.95	8.70	17.83	174.69
	*W.D.	20.1	19.2	17.1	17.5	14.2	12.4	13.8	17.2	13.7	12.9	11.1	16.7	185.9

* R = Rainfall in inches. W.D. = Wet Day.

APPENDIX B.—MONTHLY RAINFALL AND WET-DAY AVERAGES AT ALL METEOROLOGICAL STATIONS, ETC.—*continued.*

—		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly Average.
NEW BRITAIN—*continued.*														
Monthly Rainfall Average for 24 years—Monthly Wet-Day Average for 21 years.														
Rabaul	*R.	14.22	10.43	9.69	10.15	5.23	3.43	5.83	4.11	3.77	4.99	6.29	10.14	88.28
	*W.D.	20.9	12.0	19.0	18.7	13.5	12.7	15.0	14.4	13.0	12.6	15.3	18.3	185.4
Monthly Rainfall Average for four years—Monthly Wet-Day Average for four years.														
Rapopo	*R.	11.04	6.37	10.05	6.89	5.75	3.97	4.75	8.03	3.89	6.21	6.54	8.14	81.63
	*W.D.	12.7	9.0	13.2	11.2	11.2	9.0	12.2	12.5	8.0	10.0	12.2	12.0	133.2
Monthly Rainfall Average for four years—Monthly Wet-Day Average for four years.														
Sum Sum Plantation ..	*R.	6.86	4.51	7.20	6.90	14.25	6.79	20.34	21.80	12.19	11.93	10.14	9.51	132.42
	*W.D.	15.2	9.5	15.2	10.0	18.7	17.7	22.7	19.2	21.0	15.7	16.0	14.5	195.4
Monthly Rainfall Average for nineteen years—Monthly Wet-Day Average for thirteen years.														
Talasea	*R.	32.20	28.81	23.46	19.53	7.82	5.15	5.49	4.99	5.45	8.04	11.09	19.18	171.21
	*W.D.	23.0	20.2	18.6	15.3	10.0	7.4	7.6	7.6	7.6	9.1	10.8	16.5	144.7
Monthly Rainfall Average for six years—Monthly Wet-Day Average for six years.														
Tobera	*R.	8.98	7.72	9.61	10.52	4.21	2.81	7.07	6.69	3.50	4.61	8.10	6.96	80.78
	*W.D.	19.7	17.5	21.7	19.5	11.0	12.2	14.2	13.3	13.2	11.7	17.5	18.5	190.0
Monthly Rainfall Average for thirteen years—Monthly Wet-Day Average for thirteen years.														
Watnabara	*R.	12.78	10.25	10.03	11.81	8.15	8.77	11.69	11.32	8.76	9.79	8.31	9.02	120.68
	*W.D.	21.0	16.9	18.7	17.4	14.7	11.1	19.8	18.3	14.8	15.2	13.8	15.3	197.0
MOROBE.														
Monthly Rainfall Average for six years—Monthly Wet-Day Average for six years.														
Bulolo	*R.	4.24	4.07	6.06	5.92	2.91	2.29	3.70	4.25	4.77	4.39	6.20	6.26	55.06
	*W.D.	13.8	11.8	14.8	15.0	12.3	12.7	16.0	15.8	15.8	13.2	15.8	15.2	17.22
Monthly Rainfall Average for three years—Monthly Wet-Day Average for three years.														
Baiune	*R.	4.08	8.09	8.06	5.43	4.25	2.37	4.51	3.33	6.44	4.04	8.16	6.63	65.90
	*W.D.	13.5	16.0	17.5	14.7	13.7	9.3	14.0	13.0	18.0	13.3	14.7	14.3	172.0

* R = Rainfall in inches. W.D. = Wet Day.

APPENDIX B.—MONTHLY RAINFALL AND WET-DAY AVERAGES AT ALL METEOROLOGICAL STATIONS, ETC.—*continued.*

—		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly Average.
MOROBE—*continued.*														
Monthly Rainfall Average for seven years—Monthly Wet-Day Average for seven years.														
Edie Creek	*R.	8.22	7.97	12.46	12.16	6.67	4.38	6.32	5.92	8.71	8.26	10.57	14.66	106.30
	*W.D.	†	†	†	†	†	†	†	†	†	†	†	†	†
Monthly Rainfall Average for nine years—Monthly Wet-Day Average for nine years.														
Kaiapit	*R.	8.91	8.75	13.59	12.46	5.24	2.17	2.40	2.49	3.54	5.15	7.46	11.97	84.13
	*W.D.	19.4	15.2	21.6	20.3	15.8	9.7	11.7	13.9	14.2	12.2	15.4	21.4	190.8
Monthly Rainfall Average for three years—Monthly Wet-Day Average for three years.														
Ramu	*R.	5.56	7.04	9.50	8.04	4.80	9.35	3.49	3.93	4.28	3.77	8.04	10.77	78.57
	*W.D.	†	†	†	†	†	†	†	†	†	†	†	†	†
Monthly Rainfall Average for thirteen years—Monthly Wet-Day Average for thirteen years.														
Sattleberg	*R.	4.98	5.93	6.82	8.63	20.05	17.92	25.78	28.68	26.22	12.95	11.85	6.74	176.55
	*W.D.	16.2	17.0	17.6	20.4	23.0	22.7	25.9	26.2	24.0	21.7	20.0	18.6	253.3
MADANG.														
**Monthly Rainfall Average for two years—Monthly Wet-Day Average for two years.*														
Kulili Kar Kar	*R.	14.43	14.60	17.73	11.09	11.33	6.52	4.83	6.41	6.33	12.97	23.38	16.51	146.13
	*W.D.	25.5	22.0	14.5	19.0	20.0	14.0	14.5	16.0	17.0	21.0	21.5	16.6	251.5
Monthly Rainfall Average for nineteen years—Monthly Wet-Day Average for nineteen years.														
Madang	*R.	12.05	11.69	14.64	17.03	15.15	10.32	7.79	4.62	5.19	9.38	18.92	14.48	141.26
	*W.D.	19.4	17.8	20.7	20.4	19.4	17.3	14.0	9.0	14.2	13.2	16.3	19.5	201.2
NEW IRELAND.														
Monthly Rainfall Average for nineteen years—Monthly Wet-Day Average for seven years.														
Kavieng	*R.	11.23	11.39	10.72	12.04	10.70	8.97	9.74	9.82	7.56	8.84	9.37	10.33	120.71
	*W.D.	16.3	16.4	16.9	16.4	15.9	15.5	16.9	16.5	14.3	15.6	15.4	16.5	1921·6

* R = Rainfall in inches. W.D. = Wet Day. † Not recorded.

APPENDIX B.—MONTHLY RAINFALL AND WET-DAY AVERAGES AT ALL METEOROLOGICAL STATIONS, ETC.—*continued.*

—		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly Average.
NEW IRELAND—*continued.*														
Monthly Rainfall Average for thirteen years—Monthly Wet-Day Average for thirteen years.														
Kalili Plantation	*R.	21.64	13.63	16.69	11.53	11.65	12.34	21.13	15.98	15.19	17.22	12.97	19.81	189.78
	*W.D.	21.1	18.3	18.6	16.1	15.9	17.2	20.8	22.0	16.9	17.7	15.4	16.6	216.6
Monthly Rainfall Average for nineteen years—Monthly Wet-Day Average for thirteen years.														
Namatanai	*R.	19.46	17.45	15.85	14.19	8.98	7.53	9.10	6.73	5.79	8.86	10.54	16.99	141.47
	*W.D.	20.2	18.8	18.4	15.5	13.0	11.2	12.8	11.5	10.6	11.1	13.6	16.1	172.8
Monthly Rainfall Average for four years—Monthly Wet-Day Average for four years.														
Put Plantation	*R.	9.05	8.05	12.48	16.66	11.74	9.72	15.33	14.75	14.65	12.50	11.09	10.93	146.95
	*W.D.	18.7	17.7	20.5	23.5	20.0	21.2	24.0	23.7	20.7	20.7	15.3	15.7	241.7
KIETA.														
Monthly Rainfall Average for twenty years—Monthly Wet-Day Average for twenty years.														
Kieta	*R.	10.71	11.16	10.52	11.57	9.62	9.50	11.11	10.50	8.47	10.82	9.16	9.48	122.62
	*W.D.	19.3	19.7	19.2	17.6	17.1	16.9	17.7	15.9	16.1	17.1	15.9	16.9	209.4
Monthly Rainfall Average for five years—Monthly Wet-Day Average for five years.														
Rugen Plantation	*R.	12.60	15.15	12.28	6.39	6.20	4.70	6.08	5.97	4.61	9.59	10.51	8.39	102.47
	*W.D.	20.6	19.0	16.0	13.2	14.6	13.8	19.3	18.6	12.8	17.6	13.2	16.8	195.5
SEPIK.														
Monthly Rainfall Average for sixteen years—Monthly Wet-Day Average for thirteen years.														
Aitape	*R.	10.00	10.66	10.77	10.72	8.01	6.22	6.75	6.53	4.83	6.22	7.65	10.16	98.52
	*W.D.	16.2	15.8	15.8	15.1	12.7	10.4	12.3	12.7	11.2	13.7	14.9	16.2	167.0
Monthly Rainfall Average for eight years—Monthly Wet-Day Average for eight years.														
Wewak	*R.	4.93	3.14	8.38	9.42	8.20	7.04	8.70	5.83	9.59	8.64	6.78	7.34	87.99
	*W.D.	8.7	7.0	10.4	12.3	10.2	7.6	7.1	8.5	10.5	12.0	9.1	9.9	113.3
MANUS.														
Monthly Rainfall Average for nineteen years—Monthly Wet-Day Average for nineteen years.														
Manus	*R.	10.42	11.89	11.97	14.48	10.97	13.84	17.12	16.01	10.77	11.09	11.47	10.94	150.95
	*W.D.	18.7	14.8	19.0	18.8	18.8	15.3	20.0	18.6	16.7	17.1	17.1	17.7	213.5

* R = Rainfall in inches. W.D. = Wet Day.

SUGGESTIONS FOR THE IMPROVEMENT OF NEW GUINEA COPRA.

By E. Caulfield Kelly.

THE EMPLOYMENT OF SULPHUR DIOXIDE GAS IN THE CURING OF COPRA.

Introduction.

The poor general average quality of New Guinea copra, as compared with Ceylon estate copra, to quote a single example, is due, primarily, to faulty drying and careless and improper handling of the product during the whole process of manufacture from the time the shell is split.

There are two methods of curing in general use in the Territory, viz.:—(1) Hot air drying, and (2) sun drying. Smoke drying may be disregarded for the purpose of this paper for the reason that a product, cured by this method, cannot presume to attain any category other than low-grade in the international markets, and if copra dried by hot air and sun methods were of sufficiently and consistently good quality as to command the market price of, say, Ceylon estate copra, no planter who at present advocates and adheres to the smoke-drying method could afford to disregard the advantage of discarding that crude and primitive process in favour of the more modern and lucrative hot air and sun-drying processes.

A great deal of the difficulties of turning out a really good, high-grade copra, can be traced to the handling of the product during the first few hours, after the cutting of the nuts. The extraordinary rapidity with which moulds form on freshly cut coco-nut meat must never be lost sight of, if stain or discolouration—or even worse defects—in the final product are to be avoided. This is especially so in the case of the sun-drying method, as it is not always possible to make provision for the immediate commencement of the drying process after the copra has been cut, and so counteract the growth of moulds.

Even in the case of hot air drying method, many hours frequently elapse between the cutting of the nut and the commencement of drying, especially where the copra is cut in the various paddocks of the plantation, and has to be carried in to the drier. Rainy weather adds to the trouble in such cases, as fresh water and a rain-saturated atmosphere increases the rapidity of mould action.

The Process.

The value then of some process which will at once arrest mould growth in freshly cut coco-nut meat will be appreciated and it is proposed to deal here with a simple method, which was developed some years ago by the Philippine Bureau of Science, viz., the preparation of the product by treatment with sulphur dioxide gas.

Messrs. Brill, Parker and Yeates,[1] Officers of the Bureau's Laboratory of Organic Chemistry, in describing the sulphuring process, state that the fumes not only destroy the mould spores, but remain in the meat for a sufficient time to allow for the escape of water, and prevent the growth of new mould spores. Further,

during the process of sulphuring, there is a very considerable loss of water, due to the softening of the cell walls through the action of the sulphur dioxide, which has a marked affinity for water.

Freshly cut coco-nut meat treated by this gas, may be successfully dried under cover, even without exposure to the heat of the sun or artificial heat, in two weeks (provided that there is free access of air to the product during that time), and no mould action, stain, or discolouration will take place. Naturally, of course, spreading of the meat in the sun, will greatly hasten the drying as will also the use of a hot air drier after treatment.

The Apparatus.

The sulphuring process is a very simple and inexpensive method of ensuring the out-turn of a high-grade product, and the preliminary experiments made by the Bureau of Science have been furthered by Messrs. Wells and Perkins, the Senior Officer and Chemist, respectively of the Bureau, to make possible the commercial application of the process, on small estates or plantations.

The apparatus consists of a wooden box provided with a door in one end to admit a four-wheel truck or trolley mounted on wooden or steel rails. The track is twice the length of the box. The car is provided with a framework to take a number of trays to hold the coco-nut meat to be treated. These trays may be made with split bamboo bottoms, wicker work, or even woven wire, as used in hot air driers, and they should be sufficiently separated to allow of free circulation of the gas. When the trays are loaded the car is pushed inside the box on its tracks and one kilogram (approximately 2½ lb.) of sulphur is placed in a shallow pit between the rails and under the car. If the box is made comparatively tight this amount of sulphur, when ignited, will burn for about 4 hours, liberating sufficient sulphur dioxide gas for the treatment.

At the end of the sulphur treatment the car is rolled into the open and the sulphurated material is then dried by any desired process. If spread out under cover with free access of air for a period of two weeks, it will dry slowly and produce a clean white copra, free from mould or any discolouration, which will yield an oil which is practically colourless, and free from rancidity and acidity.

The residual sulphur dioxide after one month's time may be completely disregarded, as only very slight traces will be found, and no traces will be detected in the expressed oil.

The period of two weeks for drying, mentioned above, is described only to demonstrate the preserving effect of the gas on freshly cut coco-nut meat. Naturally, if sun or artificial drying is used, the period will correspond to that required to dry copra, in the ordinary way, as if the sulphuring process had not been used.

Dimensions of Apparatus.

Wells and Perkins(2) describe in detail a handy size apparatus, capable of dealing with the meat of 3,000 nuts at one charge.

The sulphuring box inside measures 4 feet wide by 8 feet 10 inches long, by 7 feet high, made with 1 inch tongued and grooved timber, and was erected in a shed with a galvanized iron roof and dirt floor,

The whole of one of the 4-feet ends comprised a well-fitting door. Seventeen feet of wooden track was laid in a trench 8 inches deep, running into the box to take two pairs of bogey wheels of 2 feet gauge.

Sixteen trays, outside measurement 7 feet 8 inches x 3 feet x 2 inches deep, were constructed of light timber, the bottoms being made of bamboo strips, placed so as to leave a mesh of ½ inch. A light frame work was constructed on the two pairs of bogey wheels to carry these sixteen trays, with just sufficient space between them to allow of free circulation of air.

The sulphur is burned on a pan which may be made from a cut down kerosene tin or other suitable container, placed on the dirt floor under the car, when in position in the box. The loaded truck is rolled into the box, the sulphur ignited and the door tightly closed. One kilogram of sulphur is usually sufficient for one charge, and six hours in the box are sufficient for the full effect of the fumes, although the sulphur itself may only burn for four hours. It is important to note that the box should be comparatively (but not absolutely) air-tight, to permit of the slow combustion of the sulphur.

Advantages of Treatment.

Sulphured copra, properly dried, has a lighter appearance than the whitest sun-dried copra, because the sulphur partially bleaches the dark outer skin of the meat as well as preserves the natural whiteness of the inside surface. The moisture content when the copra is later dried is about 5 per cent., and the free fatty acid content less than 1 per cent. The sulphur dioxide partly evaporates during drying and partly oxidizes into sulphuric acid, but the sulphuric acid thus formed, does not remain in the oil or injure it in any way.

The direct protection afforded by sulphur dioxide does not last more than a month, but this is more than ample time to complete drying even by the most lengthy process.

Time of Treatment.

Sulphuring should be done very soon after the nuts are opened if rainy weather prevails or is anticipated. If coco-nut meat is rained upon unexpectedly, it can be sulphured even if slight mould growth has started; the mould can thus be killed and further damage prevented, but the fullest protection is afforded if nuts are cut near the box, and the meat sulphured within an hour or two of exposure.

Sulphuring is valuable, chiefly as an adjunct to the sun-drying process of curing. With well-built and systematically-operated hot air driers in good weather conditions, and where the copra is cut at the drier, it should not be necessary, but it can well be employed to supplement hot air drying in adverse weather conditions, or with home-made or faulty kilns.

It frequently happens too, that through circumstances of labour, or weather conditions, a fresh batch of meat is cut and ready to be dried before the preceding batch has been sufficiently dried to remove it from the kiln. In such cases the fresh batch of meat can be preserved against mould or discolouration by sulphuring at once, when it can be stored aside to await its turn in the drier.

Drying.

It must not be inferred that the sulphuring process in itself will dry copra, or that meat which has been treated may be bagged or even stored in heaps with impunity. Whilst sulphured coco-nut meat requires no artificial heat, or exposure to the heat of the sun for a long period after treatment, it must have free access of air, in a covered place, free from rainy weather, or extreme damp. It follows therefore, that until drying has been completed it must be spread out on a dry floor or on trays where the air can freely circulate through the pieces.

Cost of Sulphur.

The expense of sulphuring is negligible when the superior quality of the copra obtained is considered. The sulphur need not be of very refined grade; in fact crude sulphur is preferable, as impurities retard the rate of combustion, and so prolong the period of treatment, from a given weight of sulphur.

Sulphur is available in quantity either from Japan or the Philippines, and could be landed in New Guinea for approximately 15s. per cwt.—a sufficient quantity to treat about 25 tons of copra. There are also sulphur deposits in the territory itself, which could be made perhaps to yield crude sulphur at a very low cost.

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(2) A. H. Wells and G. A. Perkins; "Use of Sulphur Fumes in Copra Drying"—*Philippine Journal of Science*, XXI., 1, 1922, 49.

PESTS OF COCOA IN THE TERRITORY OF NEW GUINEA.[1]

By John L. Froggatt, B.Sc., Entomologist.

Although cocoa has been planted for a number of years in various parts of the Territory, it is only in the last few years that any appreciable expansion in the planting of this crop has taken place.

To date, this crop has been comparatively free of serious insect pest infestation, some of the trunk, stem and branch borers being the only ones of major economic importance.

Pests of the Trunk, Branch and Stem.

The most serious pest of cocoa recorded to date is the weevil or snout beetle, *Pantorhytes plutus, Oberth.*[2] (*Curculionidae*). Although this species has been collected in most parts of the Territory, it has, so far, only been recorded as a cocoa pest on portions of New Britain.

Owing to the difficulty, in many cases, of attacking the pest with mechanical measures, inquiries are in hand in reference to possible biological control.

Damage occasioned to limbs and branches by larvae of *Cerambycinae* is sufficiently common as to need careful watching. *Dictamia sp. near rugosa Pasc.* has been bred from such infested timber, but it would appear, from reports received, that there is at least one other species concerned.

The introduction of small quantities of *Paradichlorbenzene* into the grub channels will kill the larvae, the alternative being the use of a piece of thin wire inserted as a seeker into the borings to puncture, or so kill, the grubs.

Occasionally *Lepidopterous* larva and the grubs of *Orthorrhinus patruelis,* Pasc. (*Curculionidae*)(2) have been found boring in the branches, neither of which, however, appear to be numerous. The former has also been bred from the stems and main laterals of coffee trees.

Calotermes papua, Desneux (*Isoptera*) at times attacks the trunks of well-grown trees and may cause appreciable damage. This is a very large "white ant", the workers measuring three quarters of an inch in length and the adult, males and females, an inch and three quarters from the head to the tip of the folded wings. This species has also been found in the stems of old Annatto (*Bixa orellana*) bushes. A solution of paradichlorbenzene in Kerosene (in the proportion of 2 lb. to 4 gallons) poured into the workings has killed the termites without apparently harming the tree.

In Malaya, termites attacking rubber trees are treated by the fumes from arsenic and sulphur burning together being blown through the workings in the trunk. These machines cost £5 to £6 sterling.

Pests of the Foliage.

Several species of the genus *Rhyparida* (*Eumolphidae*) including *Rhyparida obscuripennis,* Jac., attack the young foliage, and where present in any numbers may affect the growth of the young twigs.

These are small brown or black beetles, which have the habit of dropping from the foliage when disturbed.

When the attack occurs on small trees this habit may be used for their collection by hand, by holding a net or tin under the infested foliage and shaking the twig, when the beetles fall into the container and can then be readily destroyed.

Platyachus ruralis, Fst. (*Curculionidae*) is a small grey weevil, which at times also feeds on the young foliage.

There are four species of moths, all belonging to the family *Noctuidae,* which have been bred from caterpillars collected on the foliage, namely *Tiracola plagiata* Wlk., *Prodenia litura,* F. and a species of the genus Erias, while a species of *Limacodidae* (Cup Moths) (as yet unidentified) has been found feeding on cocoa foliage in the Kieta district.

Tiracola plagiata is a reddish brown moth measuring about 2 inches across the outspread wings; the caterpillars are dark in colour and about 2½ inches in length.

Prodenia litura measures approximately 1¾ inches across the outspread wings, and is brown in colour with white tracery markings on the upper wings.

Erias sp. is a small yellow moth.

Two species of "*Froghoppers*" are not uncommon in both nymphal and adult forms on cocoa, but apparently do no damage to the trees; these are *Euricania splendida F* (*Ricaniidae*) and *Euphanta pokiana, Dist.*, (*Flatidae*). These insects have the habit when disturbed of "jumping" as well as flying.

Euricania splendens is generally dark brown with a green tinge in colour with transparent areas in the wings, and is about ¾ inch in length, over the folded wings. *Euphanta pokiana* is green in colour, the wings folding in rather a "tent shape"; it is also about ¾ inch in length over the folded wings.

Aphids and "*mealy bugs*" are occasionally seen on young tip foliage, but are negligible as a pest.

A small dark-coloured species of *Thysanoptera* ("Thrips"), as yet unidentified, has been collected on the foliage of young cocoa bushes on one plantation on New Britain, but has not caused any material damage; control has been obtained by spraying.

Yellowish-brown patches on the leaves indicate the presence of this insect, which is readily seen with the aid of a lens under the light covering of webbing formed by the thrips; all stages may be present at the one time. The nymphal stages are marked with two red bands across the middle of the body.

Insects Damaging the Pods.

Lepidopterous larvae have been occasionally found tunnelling in the hard casing of the pods, but difficulties have been met with in breeding out the adults; the channellings made by these caterpillars may lead to the introduction of fungous rots. "*Mealy bugs*" are sometimes present on the outside of the pods, but apparently do no material damage.

Two species of *Rutelidea, Parastasis inconstans Frm.*, and *Parastasia marmorata, Gestro.*, have been recorded as eating off the surface tissue of the pods, but are of comparatively rare occurrence. These beetles are about ¾ inch in length and have the wing covers dark reddish brown, and the thorax and head dark biscuit colour.

Control (General).

Beetles and caterpillars feeding on the foliage can be controlled by spraying or dusting with arsenicals, such as arsenate of lead; sap-sucking insects, if present in plague quantities, can be controlled with a quick-breaking type of oil spray, kerosene emulsion or lime-sulphur spray fluid.

Insect Specimens Required.

It would be of material assistance if owners of cocoa plantations would co-operate with the technical officers of the department in forwarding specimens of insects damaging *any* part of the trees; beetles and other hard-bodied insects could be forwarded in spirit; caterpillars could be placed in a ventilated box, with sufficient feeding material to enable them to live through the period of transport.

(1) We are indebted to the Imperial Bureau of Entomology for insect identifications.
(2) *Vide New Guinea Agricultural Gazette*, Volume 4, No. 1, 1938, *Weevil Pests of Cocoa.*

RELATIONSHIP BETWEEN THE WEIGHT OF HUSKED NUTS AND THE WEIGHT OF COPRA.

By E. Caulfield Kelly.

Plantation owners in the Mandated Territory of New Guinea who take a keen and intelligent interest in their properties, are probably conversant with the yield of their individual plantations, in terms of—

(*a*) Average number of nuts per ton of copra.

(*b*) Average yield of the property in terms of tons (per mensem or per annum).

When one considers, however, the very wide variation which exists on different plantations in New Guinea, in the correlation between the number of nuts dried, and the weight of copra produced, and applies this variation to an individual property, the question may well arise, as to what portions or paddocks of a property are the most profitable, and which the least productive—and why. To cite a case in point where statistics are available in the Department of Agriculture, Rabaul, one property in the North Bainings produces a ton of copra per 10,000 nuts (approximately) whilst another, on the South Coast of the same island in the Gasmata area, requires less than 5,000 nuts to produce a ton—a variation, in the coefficient, of more than 100 per cent. Still another property in the Western Islands requires 15,000 nuts per ton of copra.

Whatever may be the differences of environment as regards rainfall and soil, between the properties under consideration, it must be inferred that the major part of the discrepancy introduced is due to the variability in the size of the nuts from different palms, and more especially from different varieties of palm, in the three areas. Some varieties produce small nuts which, although present in large numbers, may produce no more copra than half the number of larger nuts from other varieties.

In the early days of European occupation of the Territory, most of the present-day fully bearing properties were planted out and hard pioneering spadework was necessary. The difficulties of the planter were both numerous and serious; hostile natives, lack of shipping facilities, lack of road communications, and slow, primitive methods of transport, made his task an enormous one. Plantations, therefore, grew by easy stages of a few hectares at a time, until a property was fully planted. Little or no attention was paid to selection of seed nuts, or to the suitability of a particular area for a specific variety of palm. Seed was obtained when required, and from whatever source available; a good deal was imported; some was purchased from native groves; and later on some was obtained from newly-established plantations in this Territory and from Papua. Most of the older properties, therefore, are a collection of small blocks of palms of different varieties, and varying slightly in age.

As the European settlement increased, and further areas were cleared and planted, the owners of the new properties looked to the newly-established plantations for their supplies of seed. Naturally, their selection fell on those properties which were yielding well, and they purchased their seed nuts accordingly. But, whereas a property might have had a satisfactory average yield, it did not follow

that every palm, or block of palms, on the property were good "mother trees". Seed, therefore, continued to be mixed, and it is very probable that this condition of affairs still obtains in the Territory.

Of supreme interest, therefore, to the careful and systematic planter of to-day, should be a detailed knowledge of his productive property, not merely computed as an average yield, but, for purposes of posterity, set out as systematic data, which provides full information as to the exact potentialities of each small group of his palms, both in the matter of nuts per palm and yield per nut. This information will not only make for better acquaintance with his plantation, but, where careful selection of seed becomes necessary, leave no doubt as to choice. Some of the older properties, too, are fast approaching the "retirement list", and the time is not far off when replanting will commence, and such data will become invaluable.

The purpose of this article is to suggest a system for the compilation of the information referred to in the previous paragraph, and to this end, great use can be made of a series of very careful experiments, recently conducted in Ceylon, under the Coco-nut Research Scheme. Many methods were tested to establish a definite correlation between the nuts from a particular palm, or group of palms, and their yield, and it was eventually ascertained that there was a remarkably close relationship between the weight of the husked nut, and the copra content. To arrive at this correlation very careful experimentation was required, and the results were arrived at only by very considerable field work. Naturally, the best expression of yield is the weight of the copra, but even if each individual planter were to be put to the trouble and expense of establishing his data by personal experimentation, it is probable that error and inaccuracy would creep in. For example, the cartage of separate lots of nuts from various parts of a property could result in mixing the nuts from different units; kiln space may be too limited to dry all the separate lots from the experimental units at one time and so ensure uniform drying; mixing and losses of pieces would always occur; errors in the scales could easily be made; great expense would be involved in curing a large number of separate parcels of nuts.

All of these difficulties are, therefore, eliminated for us by adopting the statistical results of the Ceylon experiments and applying them *in totum* to individual cases.

The experiment provided for the nuts of 260 palms of different varieties, divided into blocks of ten each, being husked, weighed, and then dried for copra. The percentage ratio between the weight of the copra and the weight of the husked nuts approximated to $33\frac{1}{3}$ per cent., which meant that in this experiment the weight of copra was approximately equal to one-third the weight of the husked nuts. In order to ascertain whether the relation between husked nut and copra, as mentioned above, could be regarded as a general relationship, the experiments were repeated on the nuts of a group of palms throughout eight picks from October, 1933, to December, 1934.

In the percentage ratio of the $\frac{\text{Wt. of copra} \times 100}{\text{Wt. of husked nuts}}$ correlation co-efficients for the individual picks were very high, approximating to $+0.98$, but the percentage ratios differed by as much as 4 per cent. in some of the picks. This big

difference may have been the result of either real discrepancies or discrepancies occasioned by lack of uniformity in drying, i.e., some picks may have been over-dried and some under-dried, thus varying the moisture content. Exhaustive experiment was then made to test for the latter discrepancy, and over a period of months the following summary was arrived at, namely:—

(*a*) it may be stated with dead-ripe nuts and optimum drying the percentage ratio between the weight of copra, and the weight of husked nuts closely approximates to $33\frac{1}{3}$ per cent.

(*b*) With uniformly ripe nuts and average drying conditions the ratio is between 32 and 33 per cent.

(*c*) Over-drying tends to lower this ratio to 30 per cent.

(*d*) For purposes of field experimentation it is recommended that 32 per cent. be adopted as the percentage ratio between weight of copra and weight of husked nuts.

NOTE.

For the benefit of factories producing desiccating coco-nut, it may be of interest to note that a commercial firm in Ceylon, which purchases coco-nuts for the manufacture of oil and desiccated coco-nut, estimates the weight of desiccated coco-nut as being approximately equal to 25 per cent. of the weight of husked nuts.

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The Tropical Agriculturist, LXXXV.: 4: 208.

CARE OF AN OLD PLANTATION.*

There comes a time in the age of a plantation when the yield begins to flag on account of the age of the trees. In some cases this age may be 40 years and in others it may not be till the trees are 60 years old. This will depend on the conditions under which the trees are grown. Under dry soil conditions where the growth and development of the trees are slow, the trees may continue to bear heavy crops till they are 60 years of age, but where the soil conditions are wet, such as in the neighbourhood of backwaters and lagoons, the trees may show sign of old-age long before this.

When this time arrives it is necessary to underplant the area with fresh seedlings, alternating with the trees already in existence. For this reason, if for no other, it is very necessary to see that the original planting of trees is carefully spaced.

Although the coco-nut tree is what is known as a light-demanding tree and does not like to be grown in the shade, the young tree is not so particular. This, after all, is nature's way of planting, and the young trees can thrive for a considerable time in the shade of other coco-nut trees. It is, however, necessary to give them a good start, and in many cases there is a necessity for manuring,

* From *The Coco-nut Palm* by H. C. Sampson, C.I.E., B.Sc.

not only to help on the young seedlings, but to prepare for the time when there arises a struggle for existence between the old and the young trees. The soil of the planting holes for the young trees should therefore be mixed with manure. This will help the seedlings to become established quickly and get beyond the dangerous age of the unsplit leaf. Before they get beyond this age they are very liable to suffer from the drip of water from the leaves of the old trees, and being grown in the still shade of the old plantation are also more liable to suffer from fungus disease. This manuring, however, causes the roots of the old trees to find their way into the manured soil in which the seedling has been transplanted, and the struggle for existence then commences. Thus, in the second year of the growth of the seedling the whole area of the plantation should be manured and this should be continued each year till the younger trees commence to form a stem. It will be found that the yield of the older trees will fall off rapidly as the younger generation of trees gain size and strength, and when the latter have formed a stem the old trees should be cut out. The young trees will not commence to fruit as long as they are in the shade of the old trees. Thus, the owner of the plantation must be prepared to forego the crop from the plantation during the interval between the felling of the old trees and the time when the younger trees come into bearing. It is easy enough to make this recommendation on paper, but it is not so easy to carry it out in practice. Some of the more vigorous of the old trees will continue to give good crops and it is not so easy to deliberately cut out such while they still are profitable trees, but it must be remembered that the young trees have much more vigor than the old trees, and when once these are allowed to come into bearing by the removal of the top shade they will very soon make good any apparent loss.

When the old trees are felled the stumps of these should at once be cut out and burnt. The centre of the stem of these stumps is quite soft and full of sap and they will only form breeding places for the much-dreaded coco-nut red weevil and the rhinoceros beetle. After this clearance the planter must decide whether or not to continue the manuring which has had to be given. If the soil is at all fertile further manuring will not be necessary. The removal of the old trees removes at the same time a heavy drain on the resources of the soil and the roots of the old crop still left in the soil will all furnish plant food for the young crop and will tend to make the latter form a deeper root system. The removal of the old crop also will render the operations of cultivation and weeding much easier and more thorough, and this in itself will tend to develop the root system of the young plantation.

By Authority: L. F. Johnston, Commonwealth Government Printer, Canberra.

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List of Plants in Cultivation in the Botanic Gardens, Rabaul.

(Including a Catalogue of the Material Available for Distribution.)

Amended nomenclature has been used except in cases where the old name is long established and well known.

Plants have been divided, as far as possible, into classes according to their uses and habits of growth, e.g., " Trees, flowering " include such trees as are particularly notable for their floral display, while other trees (which have no major economic use) are grouped under " Trees, general ".

Flowering and seeding periods are given but are approximate only and vary in accordance with the yearly variations of season and rainfall.

Every effort is made to fulfil orders, but the Department cannot guarantee the supply of all material listed.

Advice is always available as to the suitability for, and the cultivation of plants in the various districts of the Territory.

Abbreviations used—

B = Bulbs.
C = Cuttings.
M = Marcotts.
P = Plants.
R = Roots, or Rhizomes.
S = Suckers.
T = Tubers.
Y = Too young, material may be available at a later date

ECONOMIC CROPS.

—		Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart.	Material available —Price.	
						Seed.	Plants, &c.
Oils.							
Aleurites fordii Hemsl. ..	Tung oil ..	Irregular ..	Does not seed low elevations New Guinea				
Aleurites moluccana Willd. = (*Atriloba* Forst.)	Wood oil ..	March–April ..	October–January ..	60 feet	30 feet	6d. packet	
Cocos nucifera Linn.	Coco-nut ..	Continuous ..	Continuous ..	70 feet	30 feet		
Elaeis guineensis Jacq. ..	Oil palm ..	Continuous ..	Continuous ..	35 feet	30 feet	6d. packet	Large quantities special rates
Rubbers.							
Castilloa elastica Cerv. ..	Panama rubber ..	Continuous ..	Continuous ..	60 feet	35 feet	6d. packet	
Ficus elastica Roxb.	Assam rubber ..	Irregular ..	.. ..	100 feet	40 feet	..	C. 5s. per 100
Funtumia elastica Stapf ..	Lagos rubber ..	Continuous ..	Continuous ..	50 feet	30 feet	6d. packet	
Hevea brasiliensis Muell.-Arg. ..	Para rubber ..	November–December	February–April ..	60 feet	30 feet	6d. packet	
Fibres.							
Agave sisalana Perrine = (*Arigida* Mill.)	Sisal hemp ..	Irregular ..	.. ..	6 feet	6 feet	..	S. 6s.
Carludovica palmata Ruiz & Pavon	"Panama hat palm"	Continuous ..	Continuous ..	8 feet	10 feet	6d. packet	S. 6s.
Ceiba pentandra Gaertn ..	Kapok	July–August ..	October–November	50 feet	15 feet	6d. packet	
Furcraea gigantea Vent. ..	Mauritius hemp ..	Irregular ..	.. ..	6 feet	6 feet	..	S. 6s.
Musa textilis Née	Manila hemp ..	Continuous ..	.. ..	10 feet	8 feet	..	S. 6s.
Sansevieria guineensis Willd. ..	Bow string hemp	Irregular ..	Irregular ..	4 feet	5 feet	..	S. 6s.
Sansevieria zeylanica Willd. ..	Bow string hemp	Irregular ..	Irregular ..	4 feet	5 feet	..	S. 6s.
Sida rhombifolia Linn. ..	.. ..	Continuous ..	Continuous ..	5 feet	Broadcast	6d. packet	
Urena lobata Linn.	.. ..	Continuous ..	Continuous ..	5 feet	Broadcast	6d packet	
Miscellaneous.							
Coffea arabica Linn.	Coffee	Irregular ..	Irregular ..	8 feet	10 feet	2s. lb.	
Coffea robusta Linden ..	Coffee	Irregular ..	Irregular ..	8 feet	10 feet	2s. lb.	
Nicotiana tabacum Linn. ..	Tobacco ..	Continuous ..	Continuous ..	4 feet	3 feet	6d. packet	

——		Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart.	Material available—Price. Seed.	Material available—Price. Plants, &c.
MISCELLANEOUS—*continued*.							
Saccharum officinarum Linn. ..	Sugar cane ..	Irregular ..	Irregular ..	10 feet	5 feet x 4 feet	..	C. 5s. per 100
Theobroma cacao Linn. var., *criollo*	Cocoa	Continuous ..	Continuous ..	20 feet	16 feet	2d. pod	
Theobroma cacao, var. *criollo-forastero* hybrid	Cocoa	Continuous ..	Continuous ..	20 feet	16 feet	2d. pod	
SHADE TREES.							
Adenanthera pavonina Linn. ..	.. ..	November–January	March-April ..	40 feet	..	6d. packet	
Albizzia Lebbek Benth. ..	.. ..	Irregular ..	Irregular ..	50 feet	..	6d. packet	
Albizzia procera Benth. ..	.. ..	Continuous ..	Continuous ..	50 feet	..	6d. packet	
Cajanus Cajan Druce ..	Pigeon pea ..	Continuous ..	Continuous ..	15 feet	..	6d. packet	
Enterolobium Saman Prain ..	Rain tree ..	Irregular ..	Irregular ..	80 feet	..	6d. packet	
Erythrina crassifolia Koorders & Valeton	Dadap	August–September	December–January	60 feet	..	..	C. 5s. per 100
Erythrina lithosperma Blume ..	Dadap	August–September	December–January	60 feet	..	..	C. 5s. per 100
Gliricidia maculata H. B. & K.	Madero	May, June ..	September–October	45 feet	..	..	C. 5s. per 100
Leucaena glauca Benth. ..	.. ..	Continuous ..	Continuous ..	30 feet	..	9d. lb.	C. 5s. per 100
COVER CROPS.							
Calopogonium mucunoides Desv.	.. ..	March–April ..	July–October ..	Creeper	Rows 5 feet	1s. 6d. lb.	
Centrosema pubescens Benth. ..	.. ..	Continuous ..	Continuous ..	Creeper	Rows 3 feet	2s. 6d. lb.	
Mimosa invisa Mart. ..	.. ..	Continuous ..	Continuous ..	Creeper	Rows 5 feet	2s. 6d. lb.	
Pueraria javanica Benth. = (*P. phaseoloides* Benth.)	.. ..	.. ..	.. ..	Creeper	Rows 5 feet	..	C. 2s. 6d. per 100
ERECT COVER CROPS.							
Aeschynomene americana Linn.	.. ..	Continuous ..	Continuous ..	10 feet	Rows 5 feet	2s. 6d. lb.	..
Cassia laevigata Willd. ..	.. ..	Continuous ..	Continuous ..	6 feet	Rows 5 feet	2s. 6d. lb.	

Economic Crops—*continued.*

—		Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart.	Material available—Price.	
						Seed.	Plants, &c.
Erect Cover Crops—*continued.*							
Cassia occidentalis Linn.		Continuous ..	Continuous ..	3 feet	Rows 4 feet	2s. 6d. lb.	
Crotalaria anagyroides		Continuous ..	Continuous ..	12 feet	Rows 5 feet	1s. 6d. lb.	
Indigofera arrecta Hochst.		Continuous ..	Continuous ..	4 feet	Rows 4 feet	2s. 6d. lb.	
Tephrosia candida DC.		Continuous ..	Continuous ..	8 feet	Rows 5 feet	2s. 6d. lb.	
Tephrosia pumila Pers. (*T. purpurea* Pers.)		Continuous ..	Continuous ..	5 feet	Rows 3 feet	2s. 6d. lb.	
Grasses.							
Chrysopogon aciculatus Trin. ..	Love grass ..	Continuous ..	Continuous ..	1 foot	3 feet	6d. packet	R. 2s. 6d. per 100
Coelorrhachis glandulosa Stapf.	.. ..	Continuous ..	Continuous ..	3 feet	1 foot	6d. packet	R. 5s. per 100
Cymbopogon nardus Rendle ..	Citronella grass ..	.. ..	.. ..	4 feet	3 feet	6d. packet	
Cynodon dactylon Pers. ..	Couch grass ..	Continuous ..	Continuous ..	1 foot	3 feet	..	C. 5s. per 100
Melinis minutiflora Beauv. ..	.. ..	.. ..	.. ..	3 feet	3 feet	6d. packet	
Pennisetum clandestinum Hochst.	Kikuyu grass ..	.. ..	.. ..	3 feet	3 feet	..	R. 5s. per 100
Pennisetum purpureum Schum.	Merkur grass ..	Continuous ..	Continuous ..	10 feet	6 feet	6d. packet	
Vetiveria zizanioides Nash ..	Vetiver grass ..	.. ..	.. ..	3 feet	3 feet	..	R. 5s. per 100
Vegetables and Native Foods.							
Abelmoschus manihot Linn .. (*Hibiscus Manihot* Linn.)	Aibika						
Amaranthus gangeticus Linn ..	Native spinach ("Aupa")	Continuous ..	Continuous ..	3 feet	2 feet x 2 feet	6d packet	
Benincasa hispida Cogn. .. (*Cerifera Savi*)	White gourd ..	Continuous ..	Continuous ..	Climber	Trellis ..	6d. packet	T. 3s. doz.
Canna edulis Ker.-Gawl. ..	Queensland arrow-root	Continuous ..	Continuous ..	4 feet	3 feet x 2 feet	6d. packet	T. 3s. doz.
Dioscorea spp.	Yams	.. ..	.. ..	Climber	4 feet x 3 feet	..	Setts 1s. doz.

ECONOMIC CROPS—*continued.*

—		Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart.	Material available—Price. Seed.	Plants, &c.
VEGETABLES AND NATIVE FOODS—*continued.*							
Hibiscus esculentus Linn.	Okra	Continuous	Continuous	4 feet	5 feet x 1 ft. 6 in.	6d. packet	
Ipomoea Batatas Lam.	Sweet potato	..	..	Creeper	2 feet	..	C. 2s. 6d. per 100
Manihot utilissima Pohl.	Cassava	Irregular	..	6 feet	4 feet x 3 feet	..	C. 2s. 6d. per 100
Maranta arundinacea Linn.	Bermuda arrowroot	Continuous	..	2 feet	2 ft. 6 in. x 1 ft. 6 in.	..	T. 3s. doz.
Phaseolus vulgaris Linn.	Long bean	Continuous	Continuous	Climber	3 feet x 1 foot	6d. packet	
Psophocarpus tetragonobulus DC.	Wing bean	Continuous	Continuous	Climber	4 feet x 1 foot	6d. packet	
Solanum Melongena Linn.	Egg plant	Continuous	Continuous	3 feet	3 feet x 2 feet	6d. packet	
SPICES.							
Capsicum annuum Linn.	Chillies	Continuous	Continuous	3 feet	3 feet x 2 feet	6d. packet	
Cinnamomum zeylanicum Nees. (or Breyn ?)	Cinnamon	Irregular	March–April	6 feet (40 feet)	10 feet	6d. packet	P. 12s. doz.
Curcuma domestica Valeton	Turmeric	Continuous	..	2 feet	3 feet x 2 feet	..	R. 6s. doz.
Myristica fragrans Houtt (or Linn ?)	Nutmeg mace	Irregular	Irregular	60 feet	25 feet	1s. doz.	
Piper nigrum Linn.	Pepper	Continuous					
Vanilla planifolia Andr.	Vanilla	Irregular	Irregular	Climber	8 feet	..	C. 5s. per 100
EDIBLE FRUITS AND NUTS.							
Achras zapota Linn.	Sapodilla	June–August	October–December	20 feet	20 feet	6d. packet	
Aegle Marmelos Correa	Bael fruit						
Anacardium occidentale Linn.	Cashew nut						
Ananas comosus Merr.	Pineapple	..	..	2 feet	3 feet x 2 feet	..	S. 6s. doz.

ECONOMIC CROPS—*continued.*

—		Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart.	Material available—Price.	
						Seed.	Plants, &c.
EDIBLE FRUITS AND NUTS—*continued.*							
Annona Cherimolia Mill.	Cherimoyer	Continuous	Continuous	20 feet	20 feet	6d. packet	P. 12s. doz.
Annona glabra Linn.	..	Continuous	Continuous	20 feet	20 feet	6d. packet	P. 12s. doz.
Annona muricata Linn.	Soursop	Continuous	Continuous	20 feet	20 feet	6d. packet	P. 12s. doz.
Annona reticulata Linn.	"Bullock's heart"	Continuous	Continuous	20 feet	20 feet	6d. packet	P. 12s. doz.
Annona squamosa Linn.	Custard apple	Continuous	Continuous	20 feet	20 feet	6d. packet	P. 12s. doz.
Antidesma Bunius **Spreng**	..	Y ..	Y				
Artocarpus communis Forst.	Breadfruit, seeded	July–September	December–March	60 feet	35 feet	6d. packet	P. 12s. doz.
Artocarpus communis Forst.	Breadfruit, seedless variety	July–September	..	60 feet	35 feet	..	P. 24s. doz.
Artocarpus integra Merr.	Jak fruit	Continuous	Continuous	60 feet	35 feet	6d. packet	
Averrhoa bilimbi Linn.	Five corners	Continuous	Continuous	20 feet	20 feet	6d. packet	P. 12s. doz.
Averrhoa Carambola Linn.	Sweet and sour varieties	Continuous	Continuous	20 feet	20 feet	6d. packet	P. 12s. doz.
Barringtonia edulis Seem.	..	Continuous	Continuous	40 feet	30 feet	6d. packet	
Bertholletia excelsa Humb. & Bonpl.	Brazil nut	Y ..	Y				
Canarium commune Linn.	Java almond	Y ..	Y				
Canarium polyphyllum Schum.	"Galip"	March–September	September–March	60 feet	35 feet	6d. packet	
Carica Papaya Linn.	Pawpaw	Continuous	Continuous	20 feet	15 feet	6d. packet	P. 6s. doz.
Carrissa Carandas Linn.	"Natal plum"	Y ..	Y				
Chrysobalanus Icaco Linn.	"Coco plum"	Continuous	Continuous	20 feet	20 feet	6d. packet	
Chrysophyllum cainito Linn.	Star apple						
Cicca accida Merr.	..	Continuous	Continuous	20 feet	20 feet	6d. packet	
Citrus spp.	Lime ..	Continuous	Continuous	20 feet	20 feet	..	P. 12s. doz.
	Kumquat	Continuous	Continuous	20 feet	20 feet	..	P. 12s. doz.
	Orange	Continuous	Continuous	20 feet	20 feet	..	P. 12s. doz.
	Lemon..	Continuous	Continuous	20 feet	20 feet	..	P. 12s. doz.
	Mandarin	Continuous	Continuous	20 feet	20 feet	..	P. 12s. doz.
	Pomelo	Continuous	Continuous	20 feet	20 feet	..	P. 12s. doz.
Clausena Wampi Oliver	Wampee						
Cynometra cauliflora Linn.	Nam-nam	Continuous	Continuous	25 feet	20 feet	6d. packet	
Dillenia indica Linn.	..	Irregular	Irregular	40 feet	30 feet	6d. packet	
Diospyros discolor Willd.	Velvet apple	September–December	March–May	40 feet	30 feet	6d. packet	
Durio zibethinus Murr.	Durian	Y ..	Y				

ECONOMIC CROPS—*continued.*

——		Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart	Material available—Price. Seed.	Plants, &c.
EDIBLE FRUITS AND NUTS—*continued.*							
Eriobotrya japonica Lindl. ..	Loquat ..	Y	Y				
Eugenia brasiliensis Lam. ..	Brazilian cherry ..	Continuous ..	Continuous ..	15 feet	15 feet	6d. packet	P. 12s. doz.
Eugenia Jambos Linn. ..	Rose apple ..	Irregular ..	Irregular ..	45 feet	30 feet		
Eugenia jambolana Lam. ..	Java plum ..	Irregular ..	Irregular ..	60 feet	35 feet		
Eugenia javanica Lam. ..	Wax jambu ..	Y	Y				
Eugenia malaccensis Linn. ..	Malay apple ..	April–May ..	August-September	45 feet	35 feet	6d. packet	
Flacourtia indica Merr. ..	Governor plum ..	Continuous ..	Continuous ..	25 feet	25 feet	6d. packet	
Garcinia Mangostana Linn. ..	Mangosteen ..	Y	Y				
Hibiscus Sabdariffa Linn. ..	Rozelle, red and white varieties	Continuous ..	Continuous ..	8 feet	4 feet x 3 feet	6d. packet	
Inocarpus edulis Forst. ..	.. ..	December, February	April–June ..	40 feet	30 feet	6d. packet	
Lansium domesticum Jack ..	Lansat	Y	Y				
Lucuma nervosa A.D.C. = (*L. Rivicoa* Gaertn. f.)	.. ..	March–April ..	July–September ..	20 feet	20 feet	6d. packet	
Macadamia ternifolia F. Muell. ..	Queensland nut	Y	Y				
Mangifera indica Linn. ..	Mango ..	Irregular ..	Irregular ..	60 feet	35 feet	6d. packet	P. 12s. doz.
Mimusops bojeri A.D.C. ..	.. ..	Y	Y				
Monstera deliciosa Liebm. ..	.. ..	Irregular ..	Irregular ..	Epiphyte	..	..	P. 12s. doz.
Morus nigra Linn.	Mulberry ..	Irregular ..	Irregular ..	15 feet	15 feet	..	C. 3s. doz.
Muntingia Calabura Linn. ..	Japanese cherry	Continuous ..	Continuous ..	30 feet	25 feet	6d. packet	
Musa paradisica Linn. ..	Plantain ..	Continuous ..	Continuous ..	15 feet	10 feet	..	S. 6s. doz.
Musa sapientum Linn. ..	Banana ..	Continuous ..	Continuous ..	15 feet	10 feet	..	S. 6s. doz.
Nephelium Lappaceum Linn. ..	Rambutan ..	Irregular ..	Irregular ..	70 feet	40 feet	6d. packet	P. 12s. doz.
Nephelium Lit-chi Cambess ..	Litchee ..	Y	Y	35 feet	30 feet	..	M. 30s. doz.
Nephelium Longana Cambess ..	Longan ..	Irregular ..	Irregular ..	70 feet	40 feet	..	M. 30s. doz.
Passiflora edulis Sims ..	Passion fruit ..	Continuous ..	Continuous ..	Climber	10 feet	6d. packet	P. 12s. doz.
Passiflora quadrangularis Linn. ..	Granadilla ..	Continuous ..	Continuous ..	Climber	10 feet	6d. packet	P. 12s. doz.
Persea americana Mill = (*P. gratissima* Gaertn. f.)	Avocado pear ..	July–September	October–February ..	40 feet	30 feet	6d. packet	P. 12s. doz.
Psidium cattleianum Sabine ..	Cherry guava ..	Continuous ..	Continuous ..	15 feet	15 feet	6d. packet	
Psidium Guajava Linn. ..	Guava ..	Continuous ..	Continuous ..	15 feet	15 feet	6d. packet	
Punica Granatum Linn. ..	Pomegranate ..	Continuous ..	Continuous ..	15 feet	15 feet	6d. packet	
Spondias pinnata Kuntz = (*S. Mangifera* Will.)	Hog plum ..	June-September ..	January-March ..	30 feet	20 feet	6d. packet	
Tamarindus indica Linn. ..	Tamarind ..	March—May ..	June–September ..	50 feet	35 feet	6d. packet	
Zalacca edulis Blume	.. ..	.. ..	.. ..	20 feet	20 feet	..	S. 12s. doz.

—		Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart.	Material available—Price. Seed.	Material available—Price. Plants, &c.
ROCKERY, BEDDING AND POT PLANTS, FERNS.							
Achimenes grandiflora D.C.		Continuous	..	6 inches	..	..	6s. doz.
Adiantum concinnum H.B.K.		..	..	1 foot	..	..	R. 24s. doz.
Adiantum farleyense T. Moore		..	..	1 foot	..	..	R. 24s. doz.
Adiantum gracillimum T. Moore	Maidenhair ferns	..	..	1 foot	..	..	R. 24s. doz.
Adiantum peruvianum Klotzsch		..	..	1 foot	..	..	R. 24s. doz.
Adiantum trapeziforme Linn.		..	..	1 foot	..	..	R. 24s. doz.
Agave vera-cruz Mill. = (*Alurida* Ait.)	Century plant	..	..	3 feet	..	..	B. 12s. doz.
Aglaonema commutatum Schott = (*Scindapsus Cuscuaria* Presl.)		..	..	2 feet			
Aglaonema costatum N.E.Br.		..	..	6 inches			
Alocasia indica Schott							
Alsophila atrovirens Presl.	Tree ferns	..	..	10 feet			
Alsophila crenata Papl.		..	..	10 feet			
Alternanthera amoena Voss.		Continuous	..	6 inches	..	..	P. 1s. doz. C. 6d. doz.
Amorphophallus campanulatus Blume		Irregular	Irregular	3 feet	..	6d. packet	
Anthurium cristallinum Linden and André							
Anthurium macrolobium Hybrid							
Asplenium nidus (-*avis*) Linn.							
Begonia Bismarcki Hybrid		Continuous	..	2 feet	..	..	C. 3s. doz.
Begonia semperflorens Link and Otto		Continuous	..	2 feet	..	..	C. 3s. doz.
Begonia rex Putz.		Continuous	..	2 feet	..	..	P. 12s. doz. C. 3s. doz.
Begonia socatrana Hook. f.		Continuous	..	2 feet			
Billbergia pyramidalis Lindl.							
Billbergia saundersii Hort.							
Bryophyllum pinnatum Kurz = (*B. Calycinum* Salisb.)		..	..	1 foot	..	..	P. 3s. doz. C. 1s. dz.
Caladium spp.		..	..	3 inches–1 foot	..	..	B. 6s. doz.
Calathea zebrina Lindl.							

—	Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart.	Material available—Price.	
					Seed.	Plants, &c.
ROCKERY, BEDDING AND POT PLANTS, FERNS—*continued.*						
Canna indica Linn.	Continuous	Continuous	3 feet	..	..	T. / R. 6s. doz.
Cleome speciosissima Deppe	Continuous	Continuous	1 foot	..	6d. packet	
Coleus sp.	..	..	2 feet			
Crinum asiaticum Linn.	Continuous	..	2 feet	..	..	B. 6s. doz.
Crinum giganteum Andr.	Continuous	..	3 feet	..	..	B. 6s. doz.
Crinum Moorei Hook. F.	Continuous	..	2 feet	..	..	B. 6s. doz.
Crinum pedunculatum R.Br.	Continuous	..	2 feet	..	..	B. 6s. doz.
Datura metel Linn.	Continuous	Continuous	4 feet	..	6d. packet	
Dieffen bachia Bowmannii Carr	..	..	3 feet	..	..	C. 3s. doz.
Dieffen bachia magnifica Linden & Rodigas	..	..	3 feet	..	..	C. 3s. doz.
Dracaena sanderiana Hart.	..	..	3 feet	..	..	C. 3s. doz.
Dracaena Victoria Hort.	..	..	3 feet	..	..	C. 3s. doz.
Haemanthus multiflorus Martyn	Continuous	Continuous	1 foot	..	..	B. 6s. doz.
Hedychium coronarium Koenig.	Continuous	Continuous	4 feet	..	..	B. 6s. doz.
Hippeastrum reticulatum Herb.	Continuous	Continuous	2 feet	..	..	B. 6s. doz.
Hippeastrum vittatum Herb.	Continuous	Continuous	2 feet	..	..	B. 6s. doz.
Karatas Morreniana Antoine						
Karatas spectabilis Antoine						
Nelumbium speciosum Willd. = *Nymphaea lotus* Linn.	Continuous	Continuous	1 foot	..	6d. packet	
Opuntia spp.	..	..	Varies ..	..	..	C. 3s. doz.
Ruellia tuberosa Linn.	Irregular	..	2 feet	..	..	P. 6s. doz.
Selaginella flabellata Spring	..	..	6 inches	..	..	R. 6s. doz.
Selaginella umbrosa	..	..	6 inches	..	..	R. 6s. doz.
Serissa foetida Comm. = (*S. fetidaham*)	Continuous	..	2 feet	..	..	C. 3s. doz.
Sinningia speciosa Hiern	Continuous	..	1 foot	..	..	P. 6s. doz.
Spathiphyllum commutatum Schott	Continuous	..	2 feet	..	..	P. 6s. doz.
Strelitzia reginae Hort [Banks in] *Ait Hortkew*						
Torenia Fournieri Linden	Continuous	Continuous	1 foot	..	6d. packet	P. 3s. doz.
Vinca rosea Linn.	Continuous	Continuous	1 foot	..	6d. packet	
Zephyranthes rosea Lindl.	Continuous	..	6 inches	..	..	P. 3s. doz.

ECONOMIC CROPS—*continued.*

—		Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart.	Material available—Price. Seed.	Plants, &c.
CREEPERS AND SCANDENT SHRUBS.							
Abrus precatorius Linn.	Prayer-seed	Continuous	Continuous	..	..	6d. packet	
Allamanda hendersoni Bull.	..	Continuous	..	..	..	..	P. 6s. doz.; C. 3s. doz.
Antigonon leptopus Hook and Arn.	Coralita, pink and white	Continuous	Continuous	..	..	6d. packet	P. 6s. doz.
Aristolochia floribunda Lem.	Dutchman's pipe	Continuous	Continuous	..	..	6d. packet	
Aristolochia grandiflora Arruda	Dutchman's pipe	Continuous	Continuous	..	..	6d. packet	
Aristolochia hians Willd.	Dutchman's pipe	Continuous	Continuous	..	..	6d. packet	
Arrabidaea magnifica Sprague	..	Continuous	..	..	..	..	P. 12s. doz.; C. 3s. doz.
Beaumontia grandiflora Wall	..	..	..	..	..	..	C. 3s. doz.
Begonia unguis-cati Linn.	..	..	..	..	..	..	C. 3s. doz.
Begonia venusta Ker-Gawl.	..	..	..	..	..	..	C. 3s. doz.
Bougainvillaea spectabilis Willd.	Mauve	Continuous	..	..	..	..	P. 6s. doz.; C. 3s. doz.
Bougainvillaea spectabilis var. Mrs. Butt	Crimson	Continuous	..	..	..	..	P. 12s. doz.; C. 6s. doz.
Bougainvillaea spectabilis var. ***lateritia*** as *sp.* Hort	Brick red	Continuous	..	..	..	..	C. 6s. doz.
Clematis paniculata Thunb.	..	Irregular	..	..	..	..	C. 3s. doz.
Clematis triloba Henye	..	Irregular	..	..	..	..	C. 3s. doz.
Clerodendron thomsonae Balf.	..	Continuous	..	..	..	..	C. 3s. doz.
Clerodendron thomsonae var. *Balfourii* Hort.	..	Continuous	..	..	..	..	C. 3s. doz.
Clitoria Ternatea Linn.	..	Continuous	Continuous	..	..	6d. packet	P. 6s. doz.; C. 3s. doz.
Congea tomentosa Roxb.	..	December–February	..	..	..	..	
Gloriosa Rothschildiana O'Brien	..	Continuous	Continuous	..	..	6d. packet	B. 6s. doz.
Gloriosa superba Linn.	..	Continuous	Continuous	..	..	6d. packet	B. 6s. doz.
Ipomoea arborescens Sweet	..	Continuous	Continuous	..	..	6d. packet	
Landolphia Heudelotii A.D.C.	..	Continuous					
Lantana trifolia Linn.	..	Continuous	..	..	..	..	C. 3s. doz.
Loincera Caprifolium Linn.	..	Continuous	..	..	..	..	C. 3s. doz.
Macrozanonia macrocarpa Cogn.	..	April–June	July–December	..	..	6d. packet	
Mucuna Kraetkei Warb.	..	Y ..	Y				

ECONOMIC CROPS—*continued.*

—		Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart.	Material available—Price.	
						Seed.	Plants, &c.
CREEPERS AND SCANDENT SHRUBS—*continued.*							
Odontadenia speciosa Benth.	..	Y	Y				
Passiflora foetida Linn.	..	Continuous	Continuous	..	..	6d. packet	
Petrea volubilis Linn.	..	Irregular	Irregular	..	..	..	C. 3s. doz.
Piper Betle Linn.	Betel leaf	Continuous	Continuous	..	..	..	C. 3s. doz.
Piper minimum scandens	..	..	..	..	..	..	C. 3s. doz.
Pogostemon patchouly Pellet = (*P. Heyneanus* Benth.)	Patchouli	..	..	..	..	..	C. 3s. doz.
Porana paniculata Roxb.	..	Continuous	..	..	..	..	C. 3s. doz.
Quisqualis indica Linn.	..	Continuous	..	..	..	..	P. 6s. doz. C. 3s. doz.
Solanum jasminoides Paxt.	..	Continuous	Continuous	..	..	6d. packet	
Strophanthus gratus Baill.	..	Irregular	..	..	..	..	C. 3s. doz.
Strophanthus hispidus D.C.	..	Irregular	..	..	..	..	C. 3s. doz.
Tecomanthe dendrophila K. Schumm	..	Irregular	..	..	..	..	C. 3s. doz.
Thunbergia fragrans Roxb.	..	Continuous	..	..	..	..	C. 3s. doz.
Thunbergia grandiflora Roxb.	..	Continuous	..	..	..	..	C. 3s. doz.

—		Flowering period.	Seeding period.	Approximate average height.	Material and Price.		
					Seeds.	Cuttings.	Plants, &c.
FLOWERING AND ORNAMENTAL SHRUBS.							
Abutilon indicum Sweet	Pink and white varieties	Continuous	..	12 feet	..	3s. doz.	P. 6s. doz.
Acalypha godseffiana Masters	..	Continuous	Continuous	4 feet	..	3s. doz.	
Acalypha marginata Spreng.	..	Continuous	Continuous	6 feet	..	3s. doz.	
Acalypha Sanderiana Hort.	..	Continuous	Continuous	4 feet	..	3s. doz.	
Acalypha wilkesiana Muell. Arg. var. *macrophylla*	..	Continuous	Continuous	8 feet	..	3s. doz.	
Aglaia odorata Lour.	..	Continuous	Continuous	6 feet	..	..	M. 30s. doz.
Allamanda schottii Pohl.	..	Continuous	Continuous	4 feet	6d. packet	..	P. 6s. doz.

ECONOMIC CROPS—*continued.*

—		Flowering period.	Seeding period.	Approximate average height.	Material and Price. Seeds.	Cuttings.	Plants, &c.
FLOWERING AND ORNAMENTAL SHRUBS—*continued.*							
Allamanda violacea Gardn. = (*A. Blanchettii* A.D.C.)	..	Continuous	..	4 feet	..	3s. doz.	P. 6s. doz.
Aralia Balfouriana Hort.	..	Continuous	..	6 feet	..	3s. doz.	
Aralia filicifolia Chr. Moore	..	Continuous	..	6 feet	..	3s. doz.	
Aralia Veitchii Hort.	..	Continuous	..	6 feet	..	3s. doz.	
Barleria cristata Linn.	..	Continuous	Continuous	4 feet	6d. packet	..	P. 6s. doz.
Barleria lupulina Lindl.	..	Continuous	Continuous	3 feet	6d. packet	..	P. 6s. doz.
Bauhinia candida Roxb.	} Synonyms ? {	Continuous	Continuous	10 feet	6d. packet	..	P. 6s. doz.
Bauhinia variegata Linn		Irregular	Irregular	15 feet	6d. packet	..	P. 6s. doz.
Bauhinia megalandra Griseb.	..	Y ..	Y				
Bauhinia tomentosa Linn	..	Irregular	Irregular	15 feet	6d. packet		
Brunfelsia americana Linn.	..	Continuous	Continuous	5 feet	6d. packet	3s. doz.	
Caesalpinia pulcherrima Swartz	Bird of paradise red and yellow varieties	Continuous	Continuous	8 feet	6d. packet	..	P. 6s. doz.
Calliandra haematocephala Hassk	..	Continuous	Continuous	6 feet	6d. packet		
Cassia alata Linn.	..	Continuous	Continuous	8 feet	6d. packet	..	P. 6s. doz.
Cassia bacillaris Linn. f.	..	Continuous	Continuous	8 feet			
Cassia corymbosa Lam.	..	Y ..	Y				
Cassia glauca Lam.	..	Y ..	Y				
Clerodendron fallax Lindl.	..	Continuous	Continuous	4 feet	..	3s. doz.	P. 6s. doz.
Clerodendron fragrans R.Br.	..	Continuous	Continuous	3 feet	6d. packet	3s. doz.	P. 6s. doz.
Clerodendron Minahhassae Teijsm & Binn	..	Continuous	Continuous	6 feet	..	3s. doz.	P. 6s. doz.
Clerodendron paniculatum Linn.	..	Continuous	Continuous	6 feet	..	..	P. 6d. doz.
Codiaeum variegatum Blume	Croton	Continuous	..	6 feet	..	3s. doz.	P. 6s. doz.
Cycas Rumphii Miq.	..	Continuous	Continuous	6 feet	6d. packet		
Duranta repens Linn. = (*D. Plumieri* Jacq.)	..	Continuous	Continuous	12 feet	6d. packet	..	P. 6s. doz.
Eranthemum atropurpureum Hort.	..	Irregular	..	6 feet	..	3s. doz.	
Ervatamia coronaria Stapf.	..	Continuous	..	5 feet	..	..	P. 6s. doz.
Euphorbia heterophylla Linn	..	Continuous	Continuous	3 feet	6d. packet		
Euphorbia pulcherrima Willd.	Poinsettia	Continuous	..	10 feet	..	3s. doz.	P. 6s. doz.
Flemingia strobilifera R.Br.	..	Continuous	Continuous	5 feet	6d. packet		
Galphimia gracilis Bartl.	..	Continuous	Continuous	4 feet	6d. packet	..	P. 6s. doz.
Gardenia florida Linn. = (*G. jasminoides* Ellis')	..	Continuous	..	4 feet	..	3s. doz.	

ECONOMIC CROPS—*continued.*

——		Flowering period.	Seeding period.	Approximate average height.	Material and Price. Seeds.	Cuttings.	Plants, &c.
FLOWERING AND ORNAMENTAL SHRUBS—*continued.*							
Hibiscus Rosa-sinensis Linn.	Several colours and varieties	Continuous	..	6 feet–10 feet	..	3s. doz.	P. 6s. doz.
Hibiscus schizopetalus Hook f.	..	Continuous	..	8 feet	..	3s. doz.	P. 6s. doz.
Hydrangea Hortensia Siebold	..	Continuous	..	3 feet	..	3s. doz.	
Ixora coccinea Linn.	Red.	Continuous	Continuous	3 feet	6d. packet	3s. doz.	P. 6s. doz.
Ixora congesta Roxb.	Red	Continuous	Continuous	3 feet	6d packet	3s. doz.	P. 6s. doz.
Ixora Dixiana Hort.	Red	Continuous	Continuous	3 feet	6d. packet	3s. doz.	P. 6s. doz.
Ixora javanica DC.	Apricot	Continuous	Continuous	3 feet	6d. packet	3s. doz.	P. 6s. doz.
Ixora lutea Hutch.	Yellow	Continuous	Continuous	3 feet	6d. packet	3s. doz.	P. 6s. doz.
Ixora macrothyrsa Teijsm and Binn.	Red	Continuous	Continuous	6 feet	6d. packet	3s. doz.	P. 6s. doz.
Ixora multibracteata Pearson	White	Continuous	Continuous	6 feet	6d. packet	3s. doz.	P. 6s. doz.
Ixora occulata	Red	Continuous	Continuous	3 feet	6d. packet	3s. doz.	P. 6s. doz.
Ixora rosea K. Schum.	Pink	Continuous	Continuous	3 feet	6d. packet	3s. doz.	P. 6s. doz.
Ixora stricta Roxb.	Red	Continuous	Continuous	3 feet	6d. packet	3s. doz.	P. 6s. doz.
Jasminum sambac Soland	Jasmine	Continuous	..	4 feet	..	3s. doz.	
Jatropha podaggrica Hook	..	Continuous	..	5 feet	..	3s. doz.	
Lagerstroemia indica Linn.	Indian lilac	Irregular	..	8 feet	..	3s. doz.	P. 6s. doz.
Lagerstroemia tomentosa Presl.	..	..	..	6 feet	..	3s. doz.	
Lantana aculeatea Linn. = (*L. Camara* Linn)	Red, yellow, white	Continuous	Continuous	4 feet	..	3s. doz.	P. 6s. doz.
Macrosphyra longistyla Hook f.	..	Continuous	Continuous	8 feet	6d. packet		
Malpighia coccigera Linn.	..	Irregular	Irregular	3 feet	6d. packet		
Manihot variegata	..	Continuous	Continuous	6 feet	6d. packet	3s. doz.	
Murraya exotica Linn.	..	Continuous	Continuous	15 feet	6d. packet		P. 6s. doz.
Mussaenda frondosa Linn.	..	Continuous	..	8 feet	..	3s. doz.	
Nerium Oleander Linn.	Pink, white	Continuous	..	10 feet	..	3s. doz.	
Oncoba spinosa Forsk.	..	Continuous	Continuous	15 feet	6d. packet		
Panax fruiticosum Linn.	..	Continuous	..	6 feet	..	3s. doz.	
Plumbago capensis Thunb.	Blue	Continuous	..	2 feet	..	..	P. 6s. doz.
Plumbago indica Linn.	Scarlet	Continuous	..	2 feet	..	..	P. 6s. doz.
Plumbago zeylanica Linn.	White	Continuous	..	2 feet	..	..	P. 6s. doz.
Plumeria acutifolia Poir	Frangipani	Continuous	Continuous	15 feet	..	3s. doz.	P. 6s. doz.
Plumeria alba Linn.	Frangipani	Continuous	Continuous	15 feet	..	6s. doz.	P. 6s. doz.
Plumeria rubra Linn.	Frangipani	..	..	..	..	..	
Quassia amara Linn.	..	Continuous	Continuous	6 feet	6d. packet	3s. doz.	

ECONOMIC CROPS—*continued.*

—		Flowering period.	Seeding period.	Approximate average height.	Material and Price.		
					Seeds.	Cuttings.	Plants, &c.
FLOWERING AND ORNAMENTAL SHRUBS—*continued.*							
Randia maculata DC.		Y	Y				
Rosa sp.	Rose	Irregular					
Rhodomyrtus tomentosa Wight		Y	Y		..	6s. doz.	
Russelia juncea Zucc.		Continuous	..	5 feet	..	3s. doz.	
Sambucus canadensis Linn.		Continuous	Continuous	10 feet	6d. packet		
Solanum mammosum Linn.		Continuous	Continuous	2 feet	6d. packet		
Tecoma capensis Lindl.	Scarlet	Continuous	..	4 feet	..	3s. doz.	
Tecoma mollis H. B. & K.		Continuous					
Tecoma smithii Hybrid	Orange-red	Continuous	..	6 feet	..	3s. doz.	
Tecoma stans Juss.	Yellow	Continuous	..	15 feet	..	3s. doz.	
Tecoma velutina Lindl.		Continuous	..	12 feet	..	3s. doz.	
Thevetia neriifolia Juss.		Continuous	..	4 feet	..	3s. doz.	P. 6s. doz.
Thunbergia erecta T. Anders.		Continuous	..	4 feet	..	3s. doz.	P. 6s. doz.
Tithonia diversifolia A. Gray		Continuous	Continuous	6 feet	6d. packet		
Uroskinnera spectabilis Lindl.		Continuous	..	4 feet	..	3s. doz.	
Yucca gloriosa Linn.	Adam's needle	Irregular	..	10 feet	..	..	P. 6s. doz.
SHRUBS—GENERAL.							
Abroma augusta Linn.	"Devil's cotton"	Continuous	Continuous	10 feet	6d. packet		
Acacia catechu Willd.	Cutch	Continuous	Continuous	15 feet	6d. packet		
Acacia confusa Merr.		Y	Y				
Acacia arabica Willd.		..	..	10 feet			
Acacia sphaerocephala Cham. & Schlecht.				10 feet			
Bixa Orellana Linn.	Anatto	Continuous	Continuous	15 feet	6d. packet	..	P. 3s. doz.
Bocconia frutescens Linn.		..	..	10 feet			
Brucea amarissima Merr. (Desv.?)							
Erythroxylon nova-granatense Hieron	Cocaine	Continuous	Continuous	8 feet			
Jatropha Curcas Linn.	Physic nut	Continuous	Continuous	10 feet	..	3s. doz.	
Languas rafflesiana Burkill = (*Alpinia Rafflesiana* Wall)		Continuous	Continuous	10 feet	6d. packet	..	P. 6s. doz.
Languas regia Val. = (*Alpinia regia* Val.)		Continuous	Continuous	10 feet	6d. packet	..	P. 6s doz.
Languas variegata		Continuous	Continuous	10 feet	6d. packet	..	P. 6s. doz.

ECONOMIC CROPS—*continued*.

—	Flowering period.	Seeding period.	Approximate average height.	Material and Price.		
				Seeds.	Cuttings.	Plants, &c.
SHRUBS—GENERAL—*continued*.						
Ocimum viride Willd.	Continuous	Continuous	9 feet	6d. packet		
Pachira insignis Savign.	..	..	15 feet	..	3s. doz.	
Phyllanthus myrtifolius Moon	Continuous	Continuous	15 feet	6d. packet	..	P. 6s. doz.
Stachytarpheta jamaicensis Vahl. = (*S. indica* Vahl.)	Continuous	Continuous	15 feet			
Vitex trifolia Linn.	Continuous	Continuous	6 feet	..	3s. doz.	
BAMBOOS.						
Bambusa arundinacea Willd.	Irregular	Irregular	20 feet	..	..	R. 6s. doz.
Bambusa aurea Siebold	Irregular	Irregular	20 feet	..	..	R. 6s. doz.
Bambusa multiplex Raeusch	Irregular	Irregular	10 feet	..	..	R. 6s. doz.
Bambusa siamensis Kurz. = (*B. regia* Thoms)	Irregular	Irregular	25 feet	..	..	R. 6s. doz.
Bambusa vulgaris Schrad.	Irregular	Irregular	30 feet	..	..	R. 6s. doz.
Dendrocalamus giganteus Munro	Irregular	Irregular	80 feet	..	..	R. 6s. doz.
Dendrocalamus strictus Nees	Irregular	Irregular	30 feet	..	..	R. 6s. doz.
Gigantochloa verticillata Munro	Irregular	Irregular	80 feet	..	..	R. 6s. doz.

—		Flowering period.	Seeding period.	Approximate average height.	Material available.	
					Seeds.	Plants, &c.
TREES—FLOWERING.						
Canangium odoratum King	"Ylang-ylang"	Continuous	Continuous	40 feet	6d. packet	P. 12s. doz.
Cassia Fistula Linn.	Indian laburnum	November–February	July–September	35 feet	6d. packet	P. 12s. doz.
Cassia grandis Linn.	..	November–February	July–September	50 feet	6d. packet	P. 12s. doz.
Cassia javanica Linn.	..	Continuous	Continuous	45 feet	6d. packet	
Cassia multijuga Rich.	..	Continuous	Continuous	45 feet	6d. packet	P. 12s. doz.
Cassia nodosa Buch.-Ham.	..	November–February	July–September	35 feet	6d. packet	
Cassia siamea Lam.	..	Continuous	Continuous	45 feet	6d. packet	P. 12s. doz.
Cassia sieberiana DC.	..	November–February	July–September	20 feet	6d. packet	
Couroupita guianensis Aubl.	Cannonball tree	Continuous	Continuous	70 feet	6d. packet	P. 12s. doz.

ECONOMIC CROPS—*continued.*

—		Flowering period.	Seeding period.	Approximate average height.	Material available. Seeds.	Material available. Plants, &c.
TREES, FLOWERING—*continued.*						
Jacaranda mimosaefolia D. Don. = (*J. ovalifolia* R.Br.)		Y	Y			
Kleinhovia Hospita Linn.		Continuous	Continuous	50 feet	6d. packet	
Lagerstroemia Flos-reginae Retz.	Queen flower	Y	Y			
Lysidice rhodostegia Hance		Y	Y			
Melia Azedarach Linn.	Persian lilac	Irregular	Irregular	30 feet	6d. packet	
Michelia alba DC.		Y	Y	35 feet	..	M. 30s. doz.
Michelia Champaca Linn.	Champak	Continuous	Continuous	35 feet	6d. packet	
Monodora tenuifolia Benth.	Orchid flower	December–January	..	20 feet		
Peltophorum pterocarpum Backer		Irregular	Continuous	80 feet	6d. packet	P. 12s. doz.
Poinciana regia Boj.	Flamboyante	Irregular	Continuous	45 feet	6d. packet	
Schizolobium excelsum Vog.		Irregular	Irregular	80 feet	6d. packet	
Sesbania coccinea Poir. = (*S. grandiflora* Poir.)		Continuous	June–September	20 feet	6d. packet	
Solanum macranthum Dun.	Potato tree	Continuous	Continuous	30 feet	6d. packet	
Spathodea campanulata Beauv.	W. African tulip tree	Continuous	Continuous	100 feet	6d. packet	P. 12s. doz.
TREES, GENERAL.						
Albizzia falcata Backer		Y	Y			
Albizzia fastigiata Oliver		Y	Y			
Albizzia sumatrana (Temporary species name ? Java)		Y	Y			
Alstonia scholaris R.Br.		April–May	September–October	100 feet	6d. packet	
Araucaria Bidwilli Hook	Bunya pine	Y	Y			
Araucaria Cunninghamii Sweet		Y	Y			
Araucaria excelsa R.Br.	Norfolk Island pine					
Barringtonia racemosa Roxb.		Continuous	Continuous	50 feet	6d. packet	
Berria cordifolia Burret		February	May	40 feet	6d. packet	
Bombax ellipticum H.B. & K.		Y	Y			
Brassaia actinophylla F. Muell.		Y	Y			
Caesalpinia coriaria Willd.	"Divi-divi"	March–April	July–August	45 feet	6d. packet	
Caesalpinia Sappan Linn.		Continuous	Continuous	25 feet	6d. packet	
Calophyllum Inophyllum Linn.		May–June	October–December	40 feet	6d. packet	
Carapa guianensis Aubl.	Crabwood	Y	Y			

Economic Crops—*continued.*

—		Flowering period.	Seeding period.	Approximate average height.	Material available. Seeds.	Material available. Plants, &c.
Trees, General—*continued.*						
Casuarina equisetifolia Linn.	..	Continuous	Continuous	120 feet	6d. packet	P. 12s. doz.
Cedrela odorata Linn.	..	April–May	November–December	60 feet	6d. packet	
Cola acuminata Schott & Endl.	..	Continuous	Continuous	40 feet	6d. packet	
Crescentia Cujete Linn.	..	Continuous	.. ..	20 feet		
Cupressus funebris Endl.	..	Y	Y			
Dipteryx odorata Willd.	Tongka bean	Y	Y			
Elaeocarpus serratus Linn.	..	October–November	January–February	40 feet	6d. packet	
Enterolobium cyclocarpum Griseb.	..	Y	Y			
Erythrina variegata Linn. = (*E. indica* Lam.)	..	..	..	25 feet	..	C. 3s. doz.
Erythrophleum guineense G. Don.	..	September–October	December–January	60 feet	6d. packet	
Eucalyptus deglupta Blume	"Kamerere"	Irregular	Irregular	80 feet	6d. packet	
Eugenia grandis Wight	..	Y	Y			
Ficus gibbosa Blume	..	Continuous	Continuous	70 feet	6d. packet	
Filicium decipiens Thw.	..	Y	Y			
Firmiana colorata R.Br. = (*Sterculia colorata* Roxb.)	..	Y	Y			
Glochidion nova-guineense K. Schum.	..	Continuous	Continuous	45 feet	6d. packet	
Grevillea robusta A. Cunn.	Silky oak					
Haematoxylon campechianum Linn.	Logwood					
Heritiera littoralis Dryand	..	Continuous	Continuous	30 feet		
Hibiscus tiliaceus Linn.	..	Continuous	Continuous	30 feet	6d. packet	
Intsia bijuga Kuntze = (*Afzelia bijuga* A. Gray)	"Kwila"	October–December	January-March	70 feet	6d. packet	
Kigelia pinnata D.C.	..	September–October	November–December	50 feet	6d. packet	
Laportea Gigas Wedd.	Stinging tree					
Mangifera foetida Lour.	..	Irregular	Irregular	60 feet	6d. packet	
Melaleuca Leucadendron Linn.	..	August				
Moringa oleifera Lam. = (*M. pterygosperma* Gaertn.)	Horse radish tree	Continuous	..	50 feet	..	C. 3s. doz.
Myroxylon balsamum Druce	Balsam of Tolu	.. ..	April–May	50 feet	6d. packet	
Ochroma Lagopus Swartz	Cork wood	June–September	October–December	50 feet	6d. packet	
Octomeles sumatrana Merr. = (Octomiles *Sumatranus* Miq.)	"Erima"	Continuous	Continuous	80 feet	6d. packet	
Oroxylum indicum Vent.	..	April–May	August–October	45 feet	6d. packet	
Pandanus Leram Jones	..	Continuous	Continuous	40 feet	6d. packet	

ECONOMIC CROPS—*continued.*

—		Flowering period.	Seeding period.	Approximate average height.	Material available.	
					Seeds.	Plants, &c.
TREES, GENERAL—*continued.*						
Pandanus dubius Spreng.	..	Continuous	Continuous	30 feet	6d. packet	
Pandanus labyrinthicus Kurz.	..	Continuous	Continuous	30 feet	6d. packet	
Pandanus tectorius Soland.	..	Continuous	Continuous..	30 feet	6d. packet	
Parkia intermedia Hassk.	..	May	July–August	100 feet	6d. packet	
Parkia Roxburghii G. Don.	..	Y	Y			
Parmentiera cereifera Seem.	Candle tree	November–January	March–April	25 feet	6d. packet	
Pericopsis Mooniana Thw.	..	Y	Y			
Pometia pinnata Forst.	"Towan"	December–February	April–June	70 feet		
Pongamia pinnata Merr.	Indian beech	Continuous	Continuous..	40 feet	6d. packet	
Prosopis juliflora DC.	Mesquite					
Pterocarpus indicus Willd.	Padouk	Y	Y			
Ravenala madagascariensis J. F. Gmel.	Traveller's tree	..				
Sapindus Saponaria Linn.	Soap-berry tree	Y	Y ..	30 feet	..	S. 6s. doz.
Saraca indica Linn.	Asoka	September				
Sterculia Balanghas Linn.	..	May	August–September	40 feet	6d. packet	
Swietenia macrophylla King.	Mahogany	Y	Y			
Swietenia Mahogani Jacq.	Mahogany	Y	Y			
Tabebuia Guayacan Hemsl.	..	Y	Y			
Tectona grandis Linn.	Teak ..	Continuous	Continuous	60 feet	6d. packet	
Terminalia Catappa Linn.	"Talis"	Irregular	Irregular	50 feet	6d. packet	
Tetrapleura Thonningii Benth.	..	Y	Y			
Tripetalum cymosum K. Schum.	..	Irregular	Irregular	25 feet	6d. packet	P. 6s. doz.
Tripetalum cymosum, forma pendula	"Tambun"	Irregular	Irregular	25 feet	6d. packet	P. 12s. doz.
PALMS.						
Acoelorraphe Wrightii H. Wendl.	..	Y	Y ..	..	..	S. 30s. doz.
Areca Catechu Linn.	Betel-nut	Continuous	Continuous	40 feet	6d. packet	P. 6s. doz.
Arenga pinnata Merr.	Sugar palm	Y	Y			
Bentinckiopsis ponapensis Becc.	..	Y	Y			
Borassus flabellifer Linn.	Palmyra palm	Y	Y			
Calamus spp.	Rattan palms	Irregular	Irregular	Climbers	6d. packet	P. 6s. doz.
Caryota Rumphiana Mart.	..	Continuous	Continuous	50 feet	6d. packet	P. 6s. doz.
Chrysalidocarpus lutescens H. Wendl.	..	Continuous	Continuous	20 feet	6d. packet	P. 18s. doz.
Cocos plumosa Hook.	..	Y	Y			
Copernicia cerifera Mart.	Carnauba wax palm	Continuous	.. ..	30 feet		

ECONOMIC CROPS—*continued.*

—		Flowering period.	Seeding period.	Approximate average height.	Material available. Seeds.	Material available. Plants, &c.
PALMS—*continued.*						
Corypha umbraculifera Linn.	Talipot palm	Y	Y			
Cyrtostachys lakka Becc.	"Sealing wax" palm	Y	Y			
Jubaea spectabilis H. B. & K.		Y	Y			
Latania Commersonii J. F. Gmel.		Continuous	Continuous	30 feet	6d. packet	P. 18s. doz.
Latania Loddigesii Mart.		Continuous	Continuous	30 feet	6d. packet	P. 18s. doz.
Licuala paludosa Griff.		Continuous	Continuous	6 feet	6d. packet	
Livistona altissima Zoll.		Continuous	Continuous	70 feet	6d. packet	P. 18s. doz.
Livistona australis Mart.		Continuous	Continuous	40 feet	6d. packet	P. 18s. doz.
Livistona chinensis R.Br.		Y	Y			
Livistona Boogendorpii Hort.		Y	Y			
Livistona mariae F. Muell.		Y	Y			
Martinezia caryotaefolia H. B. & K.		Y	Y			
Metroxylon Sagu Rottb.	Sago palm	Y	Y			
Metroxylon Rumphii Mart.	Sago palm	Y	Y			
Oreodoxa oleracea Mart.	Cabbage palm	Continuous	Continuous	80 feet	6d. packet	
Oreodoxa regia H. B. & K.	Royal palm	Continuous	Continuous	70 feet	6d. packet	P. 18s. doz.
Phoenix canariensis Chabaud. Hort.		Y	Y			
Phoenix pusilla Gaertn.		Y	Y			
Phoenix reclinata Jacq.		Y	Y			
Phoenix zeylanica Trimen = *P. pusilla* Gaertn.						
Pinanga micronesica Kan.		Y	Y			
Ponapea hoshinoi Kan.		Y	Y			
Ponapea Leddermanniana Becc.		Y	Y			
Ptychosperma Macarthurii H. Wendl.		Continuous	Continuous	20 feet	6d. packet	P. 18s. doz.
Raphia Hookeri Mann & H. Wendl.		Dies after seeding		50 feet	6d. packet	
Sabal Blackburnianum Glazebrook		Continuous	Continuous	40 feet	6d. packet	
Sabal mauritiiforme Griseb. & H. Wendl.		Continuous	Continuous	40 feet	6d. packet	
Sabal Palmetto Lodd.		Continuous				
Thrinax barbadensis Lodd.		Y	Y			
Thrinax parviflora Swartz		Continuous	Continuous	20 feet	6d. packet	
Veitchia Joannis H. Wendl.		Continuous	Continuous	30 feet	6d. packet	
Verschaffeltia splendida H. Wendl.		Y	Y			
Washingtonia filifera H. Wendl.		Y	Y			

List of Plants in Cultivation in the Botanic Gardens, Rabaul.

Arranged according to their Natural Orders.

Including particulars of the material available for distribution.

The second column indicates the nature of the material which can be distributed ; the third column the time at which such material is available.

Abbreviations used :—

r.	..	roots.
s.	..	seed.
su.	..	suckers.
b.	..	bulbs.
c.	..	cuttings.
p.	..	plants.
Con.	..	Continuous.
Irr.	..	Irregular.

Pteridophyta.

Filicinae.

Adiantum concinnum H.B.K.	r.	Con.
Adiantum farleyense T. Moore	r.	Con.
Adiantum gracillimum T. Moore	r.	Con.
Adiantum peruvianum Klotzsch	r.	Con.
Adiantum trapeziforme Linn.	r.	Con.
Alsophila atrovirens Presl.	..	..
Alsophila crenata Pahl.	..	..
Asplenium nidus(-avis) Linn.	..	..
Selaginella flabellata Spring	r.	Con.
Selaginella umbrosa	r.	Con.

Gymnospermae.

Coniferae.

Araucaria Bidwilli Hook	..	..
Araucaria Cunninghamii Ait.	..	..
Araucaria excelsa R.Br.	..	..
Cupressus funebris Endl.	..	..

Cycadaceae.

Cycas Rumphii Miq.	s.	Con.

Monocotyledones.

Amaryllideae.

Agave sisalana Perrine	su.	Con.
Agave vera-cruz Mill.	su.	Con.
Crinum asiaticum Linn.	b.	Con.
Crinum giganteum Andr.	b.	Con.
Crinum Moorei Hook f.	b.	Con.
Crinum pedunculatum R.Br.	b.	Con.
Furcraea gigantea Vent.	su.	Con.
Haemanthus multiflorus Martyn	b.	Con.
Hippeastrum reticulatum Herb.	b.	Con.
Hippeastrum vittatum Herb.	b.	Con.
Zephyranthes rosea Lindl.	b.	Con.

Monocotyledones—*continued.*

Aroideae.

Aglaonema commutatum Schott		
Aglaonema costatum N.E.Br.		
Alocasia indica Schott		
Amorphophallus campanulatus Blume	s.	Irr.
Anthurium cristallinum Linden and André		
Anthurium macrolobium Hyb.		
Dieffenbachia Bowmanni Carr.	c.	Con.
Dieffenbachia magnifica Linden and Rodigas	c.	Con.
Monstera deliciosa Liebm.	p.	Con.
Spathiphyllum commutatum Schott	p.	Con.

Bromeliaceae.

Ananas comosus Merr.	su.	Con.
Billbergia pyramidalis Lindl.		
Billbergia saundersii Hort		
Karatas morreniana Antoine		
Karatas spectabilis Antoine		

Cyclanthaceae.

Carludovica palmata Ruiz & Pavon	s.su.	Con.

Gramineae.

Bambusa arundinacea Willd.	r.	Con.
Bambusa aurea Siebold	r.	Con.
Bambusa multiplex Raeusch	r.	Con.
Bambusa siamensis Kurz. = (*B. bregia* Thoms.)	r.	Con.
Bambusa vulgaris Schraed.	r.	Con.
Chrysopogon aciculatus Trin.	s.r.	Con.
Coelorrachis glandulosa Stapf.	s.r.	Con.
Cymbopogon nardus Rendle	s.	Con.
Cynodon dactylon Pers.	s.r.	Con.
Dendrocalamus giganteus Munro	r.	Con.
Dendrocalamus strictus Nees	r.	Con.
Gigantochloa verticillata Munro	r.	Con.
Imperata cylindrica Beauv.	s.	Con.
Melinis minutiflora Beauv.	s.	Con.
Pennisetum Clandestinum Hochst	r.	Con.
Pennisetum Purpureum Schum.	s.	Con.
Saccharum officinarum Linn.	c.	Con.
Vetiveria Zizanoides Nash	r.	Con.

Haemodoraceae.

Sansevieria guineensis Willd.	su.	Con.
Sansevieria zeylanica Willd.	su.	Con.

Liliaeceae.

Dracaena sanderiana Hart.	c.	Con.
Dracaena Victoriae Hort	c.	Con.
Gloriosa Rothschildiana O'Brien	s.b.	Con.
Gloriosa superba Linn.	s.b.	Con.
Yucca gloriosa Linn.	su.	Con.

Orchidaceae.

Vanilla planifolia Andr.	c.	Con.

MONOCOTYLEDONES—*continued.*

Palmae.

Acoelorraphe Wrightii H. Wendl.	su.	
Areca Catechu Linn.	s.	Con.
Arenga pinnata Merr.	s.p.	
Bentinckiopsis ponapensis Becc.		
Borassus flabellifera Linn.		
Calamus spp.	s.p.	Irr.
Caryota Rumphiana Mart.	s.p.	Con.
Chrysalidocarpus lutescens H. Wendl.	s.p.	Con.
Cocos nucifera Linn.	s.	Con.
Cocos plumosa Hook		
Copernicia cerifera Mart.		Con.
Corypha umbraculifera Linn.		
Cyrtostachys lakka Becc.		
Elaeis guineensis Jacq.	s.	Con.
Jubaea spectabilis H.B. & K.		
Latania Commersonii J. F. Gmel.	s.p.	Con.
Latania Loddigesii Mart.	s.p.	Con.
Licuala paludosa Griff.	s.	Con.
Livistona altissima Zoll.	s.p.	Con.
Livistona australis Mart.	s.p.	Con.
Livistona chinensis R.Br.		
Livistona Hoogendorpii Hort		
Livistona mariae F. Muell.		
Martinezia caryotifolia H.B. & K.		
Metroxylon sagu Rottb.		
Metroxylon Rumphii Mart.		
Oreodoxa oleracea Mart.	s.	Con.
Oreodoxa regia H.B. & K.	s.p.	Con.
Phoenix canariensis Chabaud Hort		
Phoenix pusilla Gaertn.		
Phoenix reclinata Jacq.		
Phoenix zeylanica Trimen		
Pinanga micronesica Kan.		
Ponapea hoshinoi Kan.		
Ponapea Leddermanniana Becc.		
Ptychosperma Macarthurii H. Wendl.	s.p.	Con.
Raphia Hookeri Mann & H. Wendl.	s.	
Sabal Blackburnianum Glazebrook	s.	Con.
Sabal Mauritiiforme Griseb and H. Wendl.		
Thrinax barbadensis Lodd.		
Thrinax parviflora Swartz	s.	Con.
Veitchia Joannis H. Wendl.	s.	Con.
Verschaffeltia splendida H. Wendl.		
Washingtonia filifera H. Wendl.		
Zalacca edulis Blume	su.	Con.

DICOTYLEDONES.

Acanthaceae.

Barleria cristata Linn.	s.	Con.
Barleria lupulina Lindl.	s.	Con.
Eranthemum atropurpureum Hort	c.	Con.
Ruellia tuberosa Linn.	p.	Con.

DICOTYLEDONES—*continued.*

Acanthaceae—continued.

Thunbergia erecta T. Anders	c.p.	Con.
Thunbergia fragrans Roxb.	c.	Con.
Thunbergia grandiflora Roxb.	c.	Con.
Amarantaceae.		
Alternanthera amoena Voss.	c.	Con.
Amaranthus gangeticus Linn.	s.	Con.
Anacardiaceae.		
Anarcardium occidentale Linn.	..	..
Mangifera foetida Lour.	s.	Irr.
Mangifera indica Linn.	s.p.	Con.
Spondias pinnata Kurtz = (*S. mangifera* Will.)	s.	Jan.–Mar.
Annonaceae.		
Annona Cherimolia Mill.	s.p.	Con.
Annona glabra Linn.	s.p.	Con.
Annona muricata Linn.	s.p.	Con.
Annona reticulata Linn.	s.p.	Con.
Annona squamosa Linn.	s.p.	Con.
Canangium odoratum Baill.	s.p.	Con.
Monodora tenuifolia Benth.	..	..
Apocynaceae.		
Allamanda hendersoni Bull	c.p.	Con.
Allamanda schottii Pohl.	s.c.	Con.
Allamanda violacea Gardn.	c.	Con.
Alstonia scholaris R.Br.	s.	Sept.–Oct.
Beaumontia grandiflora Wall	c.	Con.
Carissa Carandas Linn.	..	..
Ervatamia coronaria Stapf.	p.	Con.
Funtumia elastica Stapf.	s.	Con.
Landolphia Heudelotii A.D.C.	c.	Con.
Nerium Oleander Linn.	c.	Con.
Odontadenia speciosa Benth.	..	..
Plumeria acutifolia Poir.	s.c.p.	Con.
Plumeria alba Linn.	c.	Con.
Plumeria rubra Linn.	..	..
Strophanthus gratus Baill.	c.	Con.
Strophanthus hispidus DC.	c.	Con.
Thevetia neriifolia Juss.	s.p.	Con.
Vinca rosea Linn.	s.	Con.
Araliaceae.		
Aralia Balfouriana Hort.	c.	Con.
Aralia filicifolia Chr. Moore	c.	Con.
Aralia Veitchii T. Moore-Hort.	c.	Con.
Brassaia actinophylla F. Muell.	..	..
Panax fruticosum Linn.	c.	Con.
Aristolochieae.		
Aristolochia floribunda Lam.	s.	Con.
Aristolochia grandiflora Arrunda	s.	Con.
Aristolochia hians Willd.	s.	Con.

DICOTYLEDONES—*continued.*

Begoniaceae.

Begonia Bismarcki Hyb.	..	..
Begonia rex Putz.	..	..
Begonia semperflorens Link & Otto.	..	..
Begonia socatrana Hook	..	..

Bignoniaceae.

Arrabidaea magnifica Sprague	c.	Con.
Bignonia unguis-cati Linn.	c.	Con.
Bignonia venusta Ker-Gawl.	c.	Con.
Crescentia Cujete Linn.	..	..
Jacaranda mimosaefolia D. Don.	..	..
Kigelia pinnata D.C.	s.	Nov.-Dec.
Oroxylum indicum Vent.	s.	Aug.-Oct.
Parmentiera cerifera Seem.	s.	Mar.–April
Spathodea campanulata Beauv.	s.	Con.
Tabebuia Guayacan Hemsl.	..	..
Tecoma capensis Lindl.	c.	Con.
Tecoma mollis H.B. & K.	..	..
Tecoma smithii Hyb.	c.	Con.
Tecoma stans Juss.	c.	Con.
Tecoma velutina Lindl.	c.	Con.
Tecomanthe dendrophila K. Schumm.	c.	Con.

Bixineae.

Bixa orellana Linn.	s.p.	Con.
Flacourtia indica Merr.	s.	Con.
Oncoba spinosa Forsk.	s.	Con.

Burseraceae.

Canarium commune Linn.	..	..
Canarium polyphyllum Schum.	s.	Sept.–Mar.
Filicium decipiens Thw.	..	..

Capparideae.

Cleome speciosissima Deppe	s.	Con.

Caprifoliaceae.

Lonicera caprifolium Linn.	c.	Con.
Sambucus canadensis Linn.	s.	Con.

Casuarineae.

Casuarina equisetifolia Linn.	s.p.	Con.

Combretaceae.

Quisqualis indica Linn.	c.p.	Con.
Terminalia Cateppa Linn.	s.	Irr.

Compositae.

Tithonia diversifolia A. Gray	s.	Con.

Convolvulaceae.

Ipomoea arborescens Sweet	c.	Con.
Ipomoea Batatas Lam.	c.	Con.
Porana paniculata Roxb.	c.	Con.

Crassulaceae.

Bryophyllum pinnatum Kurz	c.p.	Con.

DICOTYLEDONES—*continued.*

Cucurbitaceae.

Benincasa hispida Cogn.	s.	.. Con.
Macrozanonia macrocarpa Cogn.	s.	.. Irr.

Datisceae.

Octomeles sumatrana Merr. = (*Octomiles sumatranus* Miq.)	s.	.. Con.

Dilleniaceae.

Dillenia indica Linn.	s.	.. Irr.

Ebenaceae.

Diospyros discolor Willd.	s.	.. Mar.–May

Euphorbiaceae.

Acalypha godseffiana Masters	c.	.. Con.
Acalypha marginata Spreng	c.	.. Con.
Acalypha Sanderiana Hort	c.	.. Con.
Acalypha wilkesiana Muell. Arg. var. *macrophylla*	c.	.. Con.
Aleurites fordii Hemsl.	..	.. ..
Aleurites moluccana Willd.	s.	.. Oct.–Jan.
Antidesma Bunius Spreng	..	.. ..
Cicca acida Merr.	s.	.. Con.
Codiaeum variegatum Blume	c.p.	.. Con.
Euphorbia heterophylla Linn.	s.	.. Con.
Euphorbia pulcherrima Willd.	c.p.	.. Con.
Glochidion nova-guineense K. Schum. ..	s.	.. Con.
Hevea brasiliensis Muell.–Arg.	s.	.. Feb.–April
Jatropha Curcas Linn.	c.	.. Con.
Jatropha podagrica Hook	c.	.. Con.
Manihot utilissima Pohl.	c.	.. Con.
Manihot variegata	c.p.	.. Con.
Phyllanthus myrtifolius Moon	s.p.	.. Con.

Geraniaceae.

Averrhoa bilimbi Linn.	s.p.	.. Con.
Averrhoa Carambola Linn.	s.p.	.. Con.

Gesneraceae.

Achimenes grandiflora DC.	p.	.. Con.
Sinningia speciosa Hiern.	p.	.. Con.

Guttiferae.

Calophyllum Inophyllum Linn.	s.	.. Oct.–Dec.
Garcinia Mangostana Linn.	..	.. ..
Tripetalum cymosum K. Schum.	s.	.. Irr.

Labiateae.

Leonurus sibiricus Linn.	s.	.. Con.
Ocimum viride Willd.	s.	.. Con.
Pogostemon patchouly Pellet	c.	.. Con.

Lineae [*Erythroxylaceae ?*]

Erythroxylon nova-granatense Hieron.. ..	s.	.. Con.

Laurineae.

Cinnamomum Zeylanicum Breyn	s.p.	.. Mar.–April.
Persea americana Mill.	s.p.	.. Oct.–Feb.

DICOTYLEDONES—*continued.*

Leguminosae.

Abrus precatorius Linn.	s.	Con.
Acacia catechu Willd.	s.	Con.
Acacia confusa Merr.	..	..
Acacia sphaerocephala Cham. & Schlecht	..	..
Adenanthera pavonina Linn.	s.	Mar.–April
Aeschynomene americana Linn.	s.	Con.
Albizzia falcata Backer	..	..
Albizzia fastigiata Oliver	..	..
Albizzia Lebbek Benth.	s.	Irr.
Albizzia procera Benth.	s.	Con.
Albizzia Sumatrana (Temp. sp. name Java)	..	..
Bauhinia candida Roxb. (Synon. *B. variegata* ?)	s.	Con.
Bauhinia megalandra Griseb	..	..
Bauhinia tomentosa Linn.	s.	Con.
Bauhinia variegata Linn.	s.	Con.
Caesalpinia coriaria Willd.	s.	July–Aug.
Caesalpinia pulcherrima Swartz	s.	Con.
Caesalpinia Sappan Linn.	s.	Con.
Cajanus cajan Druce	s.	Con.
Calliandra haematocephala Hassk.	s.	Con.
Calopogonium mucunoides Desv.	s.	Con.
Cassia alata Linn.	s.	Con.
Cassia bacillaris Linn., F.	..	..
Cassia corymbosa Lam.	..	..
Cassia Fistula Linn.	s.	July–Sept.
Cassia glauca Lam.	..	..
Cassia grandis Linn.	s.	July–Sept.
Cassia javanica Linn.	s.	Con.
Cassia laevigata Willd.	s.	Con.
Cassia multijuga Rich	s.	July–Sept.
Cassia nodosa Buch.-Ham.	s.	July–Sept.
Cassia occidentalis Linn.	s.	Con.
Cassia siamea Lam.	s.	Con.
Cassia sieberiana DC.	s.	July–Sept.
Centrosema pubescens Benth.	s.	Con.
Clitorea Ternatea Linn.	s.	Con.
Crotalaria anagyroides H.B. & K.	s.	Con.
Cynometra cauliflora Linn.	s.	Con.
Dipteryx odorata Willd.	..	..
Enterolobium cyclocarpum Griseb.	..	..
Enterolobium Saman Prain	s.	Irr.
Erythrina crassifolia Koonders and Valeton	c.	Con.
Erythrina lithosperma Blume ?	c.	Con.
Erythrina variegata Linn.	c.	Con.
Erythropleum guineense D. Don.	s.	Dec.–Jan.
Flemingia strobilifera R.Br.	s.	Con.
Gliricidia maculata H.B. & K.	s.	Con.
Haematoxylon campechianum Linn.	..	..
Indigofera arrecta Hockst.	s.	Con.
Inocarpus edulis Forst.	s.	Con.
Intsia bijuga Kuntze	s.	Jan.–Mar.

DICOTYLEDONES—*continued.*

Leguminosae—continued.

Leucaena glauca Benth.	..	..	.. s.c.		..	Con.
Lysidice rhodostegia Hance ..		..	..	..	..	..
Melia Azedarach Linn.	..	..	.. s.		..	irr.
Mimosa invisa Mart.	..	..	.. s.		..	Con.
Macuna Kraetkei Warb.	..	..	..	..	..	..
Myroxylon balsamum Druce		..	.. s.		..	April–May.
Parkia intermedia Hassk.	..	..	.. s.		..	July–Aug.
Parkia Roxburghii G. Don. ..		..	..	..	..	..
Pericopsis Mooniana Thw. ..		..	..	..	..	..
Peltophorum pterocarpum Backer		..	.. s.		..	Irr.
Phaseolus vulgaris Linn.	..	..	.. s.		..	Con.
Poinciana regia Boj.	..	..	.. s.		..	Irr.
Pongamia pinnata Merr.	..	..	.. s.		..	Con.
Prosopis juliflora DC.	..	..	..	..	..	..
Psophocarpus tetragonobulus DC.		..	.. s.		..	Con.
Pterocarpus indicus Willd.	..	..	..	..	..	..
Pueraria javanica Benth.	..	..	.. c.		..	Con.
Saraca indica Linn.	..	..	..	..	..	..
Schizolobium excelsum Vog.		..	.. s.		..	Irr.
Sesbania coccinea Poir.	..	..	.. s.		..	June–Sept.
Tamarindus indica Linn	..	..	.. s.		..	June–Sept.
Tephrosia candida DC.	..	..	.. s.		..	Con.
Tephrosia pumila Pers.	..	..	.. s.		..	Con.
Tetrapleura Thonningii Benth.		..	..	..	..	..

Lythrarieae.

Lagerstroemia Flos-reginae Retz		..	.. s.p.		..	Con.
Lagerstroemia indica Linn ...		..	.. c.		..	Con.
Lagerstroemia tomentosa Presl.		..	.. c.		..	Con.
Punica Granatum Linn.	..	..	.. s.		..	Con.

Magnoliaceae.

Michelia alba DC.	..	..	..	..	..	..
Michelia Champaca Linn.	..	..	.. s.		..	Con.

Malpighiaceae.

Galphimia gracilis Bartl.	..	..	.. s.		..	Con.
Malpighia coccigera Linn.	..	..	.. s.		..	Irr.

Malvaceae.

Abelmoschus manihot Linn. ..		..	.. c.		..	Con.
Abutilon indicum Sweet	..	..	.. c.		..	Con.
Bombax ellipticum H.B. & K.		..	..	..	..	..
Ceiba pentandra Gaertn.	..	..	.. s.		..	Oct.–Nov.
Durio Zibethinus Murr.	..	..	..	..	..	..
Hibiscus esculentus Linn.	..	..	.. s.		..	Con.
Hibiscus Rosa-sinensis Linn.		..	.. c.p.		..	Con.
Hibiscus sabdariffa Linn.	..	..	.. s.		..	Con.
Hibiscus schizopetalus Hook, f.		..	.. c.		..	Con.
Hibiscus tiliaceus Linn.	..	..	.. s.		..	Con.
Ochroma lagopus Swartz	..	..	.. s.		..	Oct.–Dec.
Pachira insignis Savign.	..	..	.. c.		..	Con.
Sida rhombifolia Linn.	..	..	.. s.		..	Con.
Urena lobata Linn.	..	..	.. s.		..	Con.

DICOTYLEDONES—*continued.*

Meliaceae.			
Aglaia odorata Lour.	p.	..	Con.
Carapa guianensis Aubl.	..	..	..
Cedrela odorata Linn.	s.	..	Nov.–Dec.
Lansium domesticum Jack	..	..	..
Swietenia macrophylla King	..	..	..
Swietenia Mahogani Jacq.	..	..	..
Moringeae.			
Moringa oleifera Lam.	c.	..	Con.
Myristiceae.			
Myristica Fragrans Linn.?—Houtt.	s.	..	Irr.
Myrtaceae.			
Barringtonia edulis Seem.	s.	..	Con.
Barringtonia racemosa Roxb.	s.	..	Con.
Bertholletia excelsa Humb. & Bonpl.	..	..	..
Couroupita guianensis Aubl.	s.p.	..	Con.
Eucalyptus deglupta Blume	s.	..	Irr.
Eugenia brasiliensis Lam.	s.p.	..	Con.
Eugenia grandis Wight.	..	..	..
Eugenia jambolana Lam.	..	..	..
Eugenia Jambos Linn.	..	..	..
Eugenia javanica Lam.	..	..	..
Eugenia malaccensis Linn.	s.p.	..	Aug.–Sept.
Melaleuca Leucadendron Linn.	..	..	..
Psidium Cattleianum Sabine	s.	..	Con.
Psidium Guajava Linn.	s.	..	Con.
Rhodomyrtus tomentosa Wight	c.	..	Con.
Nyctagineae.			
Bougainvillaea spectabilis Willd.	c.p.	..	Con.
Bougainvillaea spectabilis var. *laterita* as sp. Hort	c.	..	Con.
Bougainvillaea spectabilis var. Mrs. Butt	c.p.	..	Con.
Nymphaeaceae.			
Nelumbium speciosum Willd. = (*Nymphaea lotus* Linn.)	s.	..	Con.
Oleaceae.			
Jasminum sambac Soland.	c.	..	Con.
Papaveraceae.			
Bocconia frutescens Linn.	..	..	..
Passifloreae.			
Carica Papaya Linn.	s.p.	..	Con.
Passiflora edulis Sims.	s.p.	..	Con.
Passiflora foetida Linn.	s.	..	Con.
Passiflora quadrangularis Linn.	s.p.	..	Con.
Piperaceae.			
Piper Betle Linn.	..	..	..
Piper nigrum Linn.	c.	..	Con.
Plumbagineae.			
Plumbago capensis Thunb.	p.	..	Con.
Plumbago indica Linn.	p.	..	Con.
Plumbago zeylanica Linn.	p.	..	Con.

DICOTYLEDONES—*continued.*

Polygonaceae.		
Antigonon leptopus Hook & Arn.	s.p.	Con.
Proteaceae.		
Grevillea robusta A. Cunn.	..	..
Macadamia ternifolia F. Muell.	..	..
Ranunculaceae.		
Clematis paniculata Thunb.	c.	Con.
Clematis triloba Heyne.	c.	Con.
Rosaceae.		
Chrysobalanus Icaco Linn.	s.	Con.
Eriobotrya japonica Lindl.	..	..
Rubiaceae.		
Coffea arabica Linn.	s.	Con.
Coffea robusta Linden	s.	Con.
Gardenia florida Linn.	c.	Con.
Ixora coccinea Linn.	s.c.	Con.
Ixora congesta Roxb.	s.c.	Con.
Ixora Dixiana Hort.	s.c.	Con.
Ixora javanica DC.	s.c.	Con.
Ixora lutea Hutch.	s.c.	Con.
Ixora macrothyrsa Teijsm & Binn.	s.c.	Con.
Ixora multibracteata Pearson	s.c.	Con.
Ixora occulata	s.c.	Con.
Ixora rosea K. Schum.	s.c.	Con.
Ixora stricta Roxb.	s.c.	Con.
Macrosphyra longistyla Hook f.	s.	Con.
Mussaenda frondosa Linn.	c.	Con.
Randia maculata DC.	..	..
Serrisa foetida Comm.	c.	Con.
Rutaceae.		
Aegle Marmelos Correa.	..	..
Clausena Wampi Oliver	..	..
Murraya exotica Linn.	s.p.	Con
Sapindaceae.		
Nephelium lappaceum Linn.	s.p.	Irr.
Nephelium Lit-chi Cambess	..	..
Nephelium Longana Cambess	..	..
Pometia pinnata Forst.	s.	April–June
Sapindus Saponaria Linn.	..	..
Sapotaceae.		
Achras zapota Linn.	s.	Oct.–Dec.
Chrysophyllum cainito Linn.	..	.
Lucuma nervosa A.D.C. = (*L. Rivicoa* Gaertn. f.)	s.	July–Sept.
Mimusops bojeri A.D.C.	..	.
Saxifrageae.		
Hydrangea Hortensia Siebold	c.	Con.
Scrophularineae.		
Russelia juncea Zucc.	c.	Con.
Torenia Fournieri Linden	s.p.	Con.
Uroskinnera spectabilis Lindl.	c.	Con.

DICOTYLEDONES—*continued.*

Simarubeae.

Brucea amarissima Desv. ? Merr.	s.	Con.
Quassia amara Linn.	s.	Con.

Solanaceae.

Brunfelsia americana Linn.	s.	Con.
Capsicum annum Linn.	s.	Con.
Datura metel Linn.	s.	Con.
Nicotiana Tabacum Linn.	s.	Con.
Solanum jasminoides Paxt.	s.	Con.
Solanum macranthum Dun.	s.	Con.
Solanum mammosum Linn.	s.	Con.
Solanum Melongena Linn.	s.	Con.

Sterculiaceae.

Abroma augusta Linn.	s.	Con.
Cola acuminata Schott & Endl.	s.	Con.
Firmiana colorata R.Br.	..	..
Heritiera littoralis Dryand.	s.	Con.
Kleinhovia Hospita Linn.	s.	Con.
Sterculia Balanghas Linn.	s.	Aug.–Sept.
Theobroma cacao Linn var *criollo*	s.	Con.
Theobroma cacao Linn. var *criollo forastero* hybrid	s.	Con.

Tiliaceae.

Berria cordifolia Burret.	s.	May
Elaeocarpus serratus Linn.	s.	Jan.–Feb.
Muntingia Calabura Linn.	s.	Con.

Urticaceae.

Artocarpus communis Forst.	s.p.	Dec.–Mar.
Artocarpus integra Merr.	s.	Con.
Castilloa elastica Cerv.	s.	Con.
Ficus elastica Roxb.	c.	Con.
Ficus gibbosa Blume.	s.	Con.
Laportea Gigas Wedd.	p.	Con.
Morus nigra Linn...	c.	Con.

Verbenaceae.

Clerodendron fallax Lindl.	c.	Con.
Clerodendron fragrans R.Br.	s.c.	Con.
Clerodendron Minahhassae Teijsm. & Binn.	c.	Con.
Clerodendron paniculatum Linn.	p.	Con.
Clerodendron Thomsonae Balf. f.	c.	Con.
Clerodendron Thomsonae var. *balfourii*	c.	Con.
Congea tomentosa Roxb.	c.	Con.
Duranta repens Linn. = (*D. plumieri* Jacq.)	s.	Con.
Lantana aculeata Linn.	c.p.	Con.
Lantana trifolia Linn.	c.	Con.
Petrea volubilis Linn.	c.	Con.
Stachytarpheta jamaicensis Vahl.	s.	Con.
Tectona grandis Linn.	s.	Con.
Vitex trifolia Linn.	c.	Con.

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